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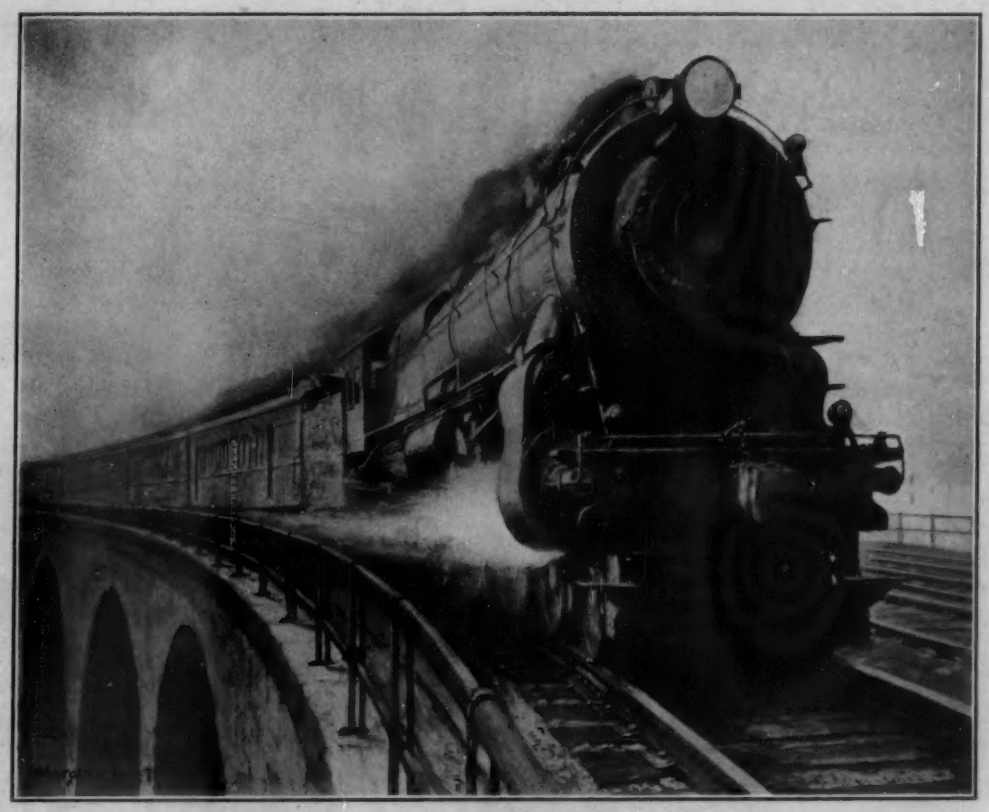

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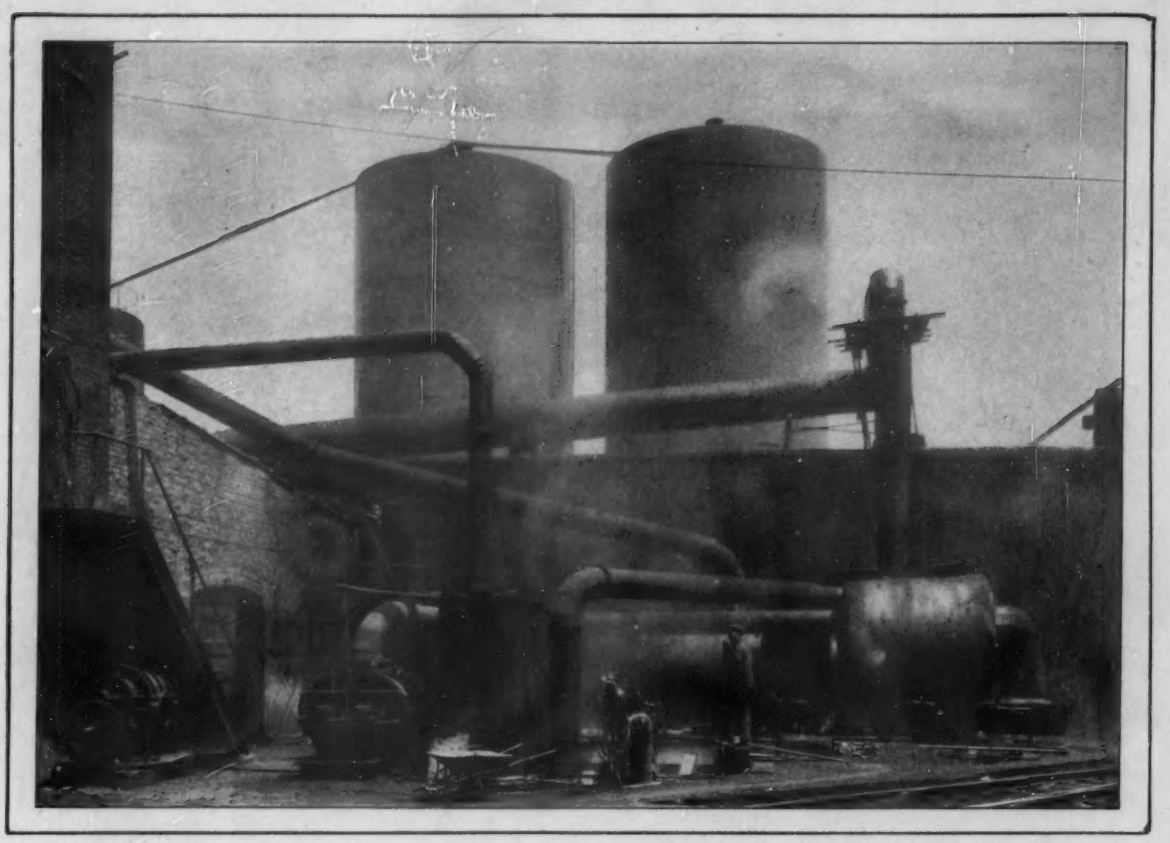

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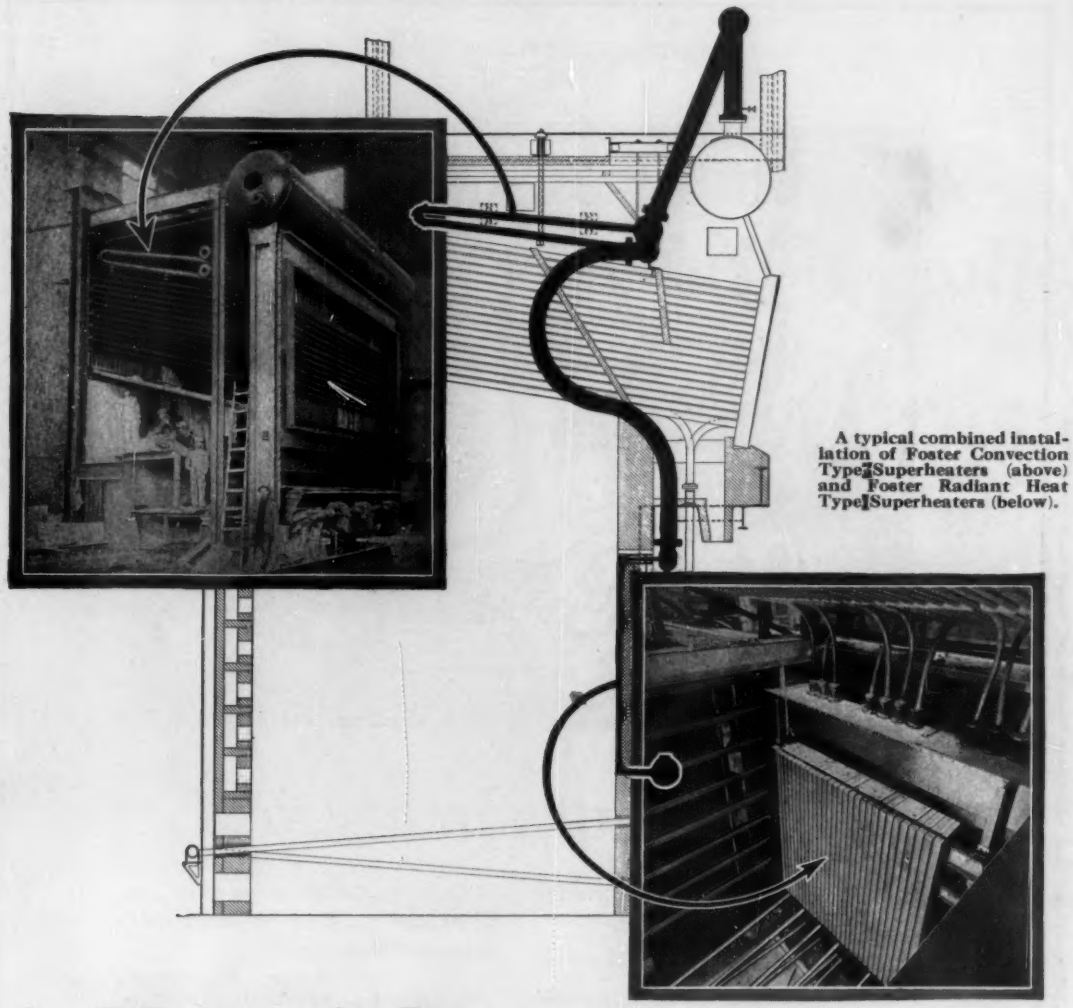

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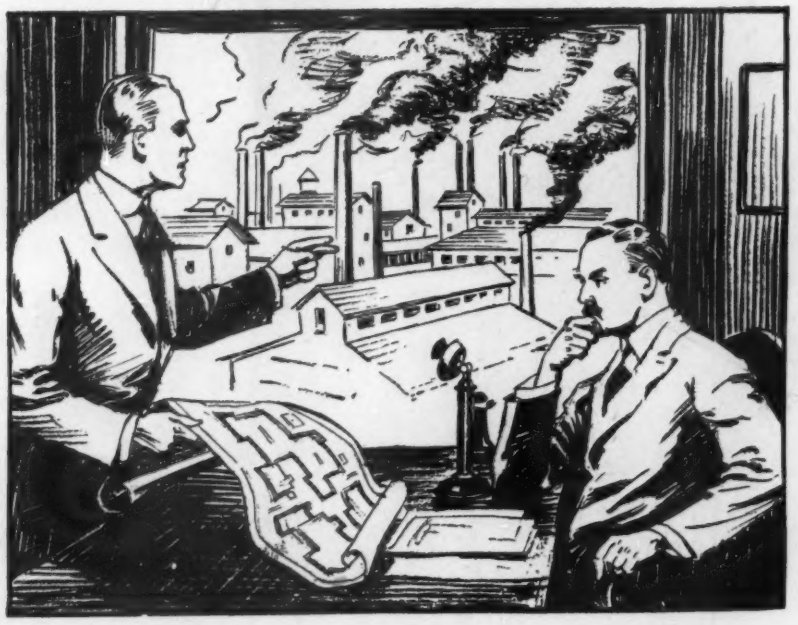

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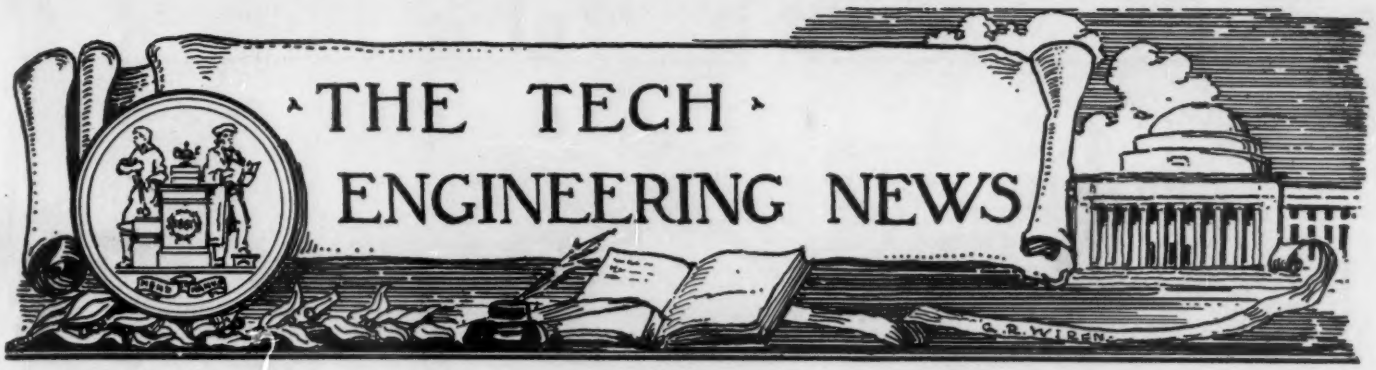

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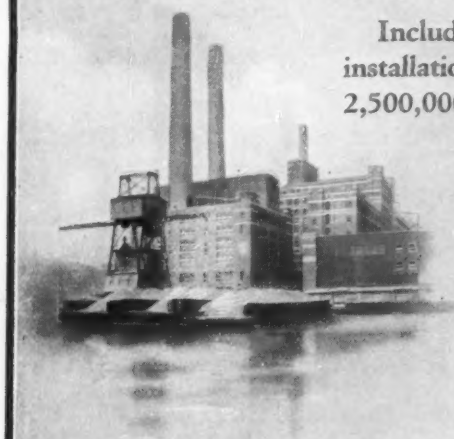

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VOLUME VII APRIL, 1926 NUMBER 2

The Technical Graduate in the Textile Industry

An interesting and frank account of the opportunities in this field for the graduates of engineering courses

By JOHN A. COLLINS, JR., '97

As a preliminary to the discussion of the real subject of this article—the opportunities for the technical graduate in the textile industry—let us first outline the several classes of textile plants in order that we can better understand the extent of the demand for technical men. We will consider only those plants using the cotton and wool fiber.

The cotton goods manufacturing system of the country is made up of several types of plants. First there is the gray goods plant in which the raw cotton is cleaned, carded, spun, and woven into some form of cloth. This cloth is then sent in the gray or unbleached condition to a cotton-finishing plant where it is bleached, dyed, printed, and finished (or any combination of these processes as may be ordered) ready for the trade. Another class of plant will dye the raw cotton and then proceed as before, or the stock may be dyed when it is in the form of yarn, but in each case the cloth as a rule will be completely finished in the same plant. A third class of plant will make the yarn only, doing no weaving, but sometimes dyeing and finishing the yarn. This yarn will then be shipped to the knitting mills to be made into hosiery and underwear. Much of it is used in the gray and much of it is dyed before it goes to the knitting mills. The separate finishing plants to which we have just referred do not as a rule own any cloth in process, but accept any goods sent them to be finished provided they have the necessary machinery. There are a few large plants, mostly in the North and East, that not only make the cotton cloth, but do all the required finishing work; but these plants are not many in number.

With the manufacturers using wool we find a somewhat different classification. A plant will make either woolen or worsted fabrics, and almost invariably the mills that weave the cloth do the dyeing and finishing work. Many mills, however, make only the yarn, and this is in turn purchased by the weaving mills that weave and finish the fabrics. The larger plants start with the raw wool and end with the fabric ready to ship to the trade. In the woolen and worsted industry there are more mills that make and finish the fabric complete than there are in the cotton industry.

This article is the fifth of a series to discuss the future of the technical graduate in various professional fields. It is hoped that this series will be of interest to the men in all classes who are confronted with the problem of deciding just what field of activity they will enter upon graduating. Mr. Collins is the Asst. Supt. of one of our largest New England textile mills and is well qualified to write a paper of this type. The sixth article of the series, to appear in the May issue, will be written by Leroy D. Peavey, '98, on "The Economic Values to be Considered in the Choice of a Profession."

We have given thus the details of these classes of plants because of the important bearing that the different conditions have on the opportunities for the technical graduate. It is undoubtedly true that the textile industry has lagged behind the other major industries of the country in development and research work, and in the adoption of new methods of manufacturing and processing. There are a number of probable reasons for this. One is perhaps the conservatism that is so characteristic of the New England personality, for the textile industry first began in New England, and today constitutes the greater part of its industries. Another reason may be that due to the nature of the processes involved there is but little chance for improvement in many of them, and this fact has retarded the development and research in those processes that really are in need of such.

A textile mill using either cotton or wool will have a considerable number of types of machines, and there will be many machines of each type. These machines, particularly in the manufacturing processes proper, are as a rule highly developed, finely made, and largely automatic. There is but little left that can be improved upon. One employee operates a number of machines, and much of the labor is unskilled. Beginning with the loom, however, the demand for skilled help appears, particularly in those mills making the finer grades of cotton fabrics, and in practically all mills making woolen, worsted, and silk cloths.

When we consider the operations subsequent to the making of the fabric—and by this we mean all the bleaching, dyeing, printing, and finishing work—we find a greater demand for skilled help and for specialized handling. The number of types of machines increases, but the machines are fewer in number and there are often more than one operator to a machine. Many of the desired effects on cloths are obtained only by elaborate treatment that calls not only for expert supervision but for expert handling on the part of the operator.

What is the present condition as regards the number of technical gradu-

(Continued on page 78)

Engineering Measurement Standards

The importance of standards of measurements in the engineering world

By EARL BUCKINGHAM

Associate Professor of Engineering Standards and Measurements, Massachusetts Institute of Technology

THE term "Engineering Standard" is generally understood to refer primarily to accepted dimensional standards, such as screw-thread standards, for example. Standards which refer to the composition and physical characteristics of materials are commonly known as "Standard Specifications," such as steel specifications; while standards which refer to methods of procedure are commonly known as "Standard Codes," such as power-test codes, boiler codes, building codes, etc. Strictly speaking, all of these are engineering standards. This discussion, however, will deal only with the subject of dimensional standards.

Interchangeable manufacturing, quantity production, and standardization go hand in hand. Before any product can be manufactured in quantity or on an interchangeable basis, definite standards must be originated for each individual part of this product. At first, such standards were peculiar to each individual manufacturing plant, but later many of them became common to several plants. As examples of such common standards we have the conventional screw threads, taper pins, bolts, nuts, rivets, etc.

We seldom stop to think of the large part that this standardization plays in our daily lives. If it did not exist, all but the very wealthy would do without many of the conveniences which are now considered necessities. Without it, every time that it was necessary to replace an electric light bulb, for example, a copy of the screw shell of the old one would have to be made to order. The same would be true whenever it was necessary to replace a water faucet, or any other metal part used in the house or in industry.

The fear is sometimes expressed that standardization will tend to monotony. This comes from an imperfect knowledge of the nature and purpose of standardization. For example, the sizes of building bricks are fairly well standardized. This does not result, however, in all brick buildings looking alike. There is an infinite number of arrangements and combinations that can be made when using these bricks of standard size so that it is not necessary to use the same combinations always. The proper scope of dimensional standards is limited to details and elements, and should seldom include more than this.

Many machine designers sometimes seem to fear that the extensive adoption and use of standards will limit their initiative and curtail their originality. Yet no one ever hears an architect complaining that the adoption of standard sizes of bricks, structural steel members, pipes, plumbing fittings, electrical fixtures, etc., has limited their originality in the design of new buildings. As a matter of fact, the adoption of these standards has relieved them of a large amount of drudgery on minor details, and has left their minds clear for the more important creative work. It is not so much the details themselves, but rather the effective arrangement and use of these details that constitutes original and creative effort.

Technique of measurements, or skill in the art of measuring, is an important part of every engineer's equipment. First essential to acquire this skill is a full understanding of the purpose and nature of measurement. The object of this series of short papers is to present briefly some of the fundamentals of this subject. The first article dealt with the measurements themselves and the fundamental units of time, space, and mass. In this issue Mr. Buckingham has treated the application of these fundamental units in defining specific engineering standards. The third article, to appear in the May issue, will deal with the problem of testing or actual measurement in order to insure the maintenance of these specific engineering standards.

At the present time the subject of standardization is receiving world-wide attention. It is becoming more and more apparent that standardization is one of the most effective means of promoting efficient and economical production. The advantages and economies of standardization should be self-evident. For one thing, standardization makes it possible to manufacture parts in larger quantities. The production of these larger quantities enables much more time and thought to be given to the methods employed to produce them. This in turn makes it possible, not only to produce them more economically, but also better, both as regards their accuracy, materials, and finish.

These dimensional standards are defined in terms of some unit of measure. The whole practice of present-day manufacturing is incontestably bound with the establishment of definite limits of measure. The manufacturer has found not only that it is to be an advantage in cheap assembly, etc., but also that his customer invariably requires a guarantee of satisfaction expressed by such limits. Thus between the manufacturer and the customer limits of measure immediately assume a new value. These dimensional standards, therefore, must include not only the expression of the nominal dimensions, but also the nature and extent of permissible variations. With this standard as common ground, both manufacturer and purchaser may bank on ultimate satisfaction; the one may guarantee his product with assurance, and the other may make certain that he receives what he pays for.

In essence, modern production methods consist of reducing as many of the details as possible to simple routine. Thus the manufacturing operations themselves are reduced to simple elementary tasks which require relatively little thought or skill on the part of the operator to perform them. At the present time, American manufacturing methods are in an interesting stage of evolution. Only a comparatively short time ago, nearly every workman employed in a machine shop was a machinist who was capable of operating any of the machine tools and who required but little more than a rough sketch in order to produce the product desired. The information which was not given him was furnished from his own knowledge and experience. This practice still continues to a greater or less extent in plants that produce a wide and varied line of products in small quantities. On the other hand, where a plant is specializing on a large production of a single commodity, few if any skilled mechanics are employed on the actual productive operations. It should be evident that the information in regard to the product required under these conditions must be much more detailed and complete than that required in a plant employing skilled mechanics in the actual production.

The development of this information for quantity production is nothing more than the adoption of definite standards for each detailed part of the mechanism to be produced. The exact nature of these standards usually depends upon the manufacturing facilities which are available. The attempt is made here to employ the most economical processes possible. This represents the first stage of standardization. Here the individual parts are standardized to serve their specific purpose in the one product.

The second stage is the development of shop standards that are used in all of the products of a single plant. These standards include completely finished parts and also standard sizes and shapes of surfaces used on different parts. The major object of shop stand-

(*Continued on page 82*)

Present-Day Problems of Railroad Management

Railroad problems as seen from the viewpoint of the executive

By ELISHA LEE, '92
Vice-President in Charge of Operation, Pennsylvania Railroad

THE great problems of railroad management today are largely those of human relationships. This situation is in sharp contrast to the demands on railroad officers of an earlier era, when new lines were being projected and constructed in all directions, and mechanical inventions were causing a rapid succession of basic changes in equipment and methods of operation. The problems of that day were in great measure those of the technician. Technical knowledge and training are still indispensable to the railroad executive. But the practical work of administration, under present conditions, is far more often concerned with devising ways and policies for the successful handling of *people*, in the mass, than with the solution of purely scientific or technical problems.

A railroad management which measures up to the job today must first of all be capable of assuming the leadership of a veritable army of employees, on large systems numbering from 100,000 to 200,000 persons. The management must understand how to keep this army loyal, industrious, and satisfied, as a primary requisite to efficient service.

Management must know how to win and hold the goodwill of a great body of patrons. This entails a grasp of the public mind, or of what we call group psychology. It means, also, mastery of successful large-scale salesmanship, because the business of running a railroad is not merely producing, but selling, transportation service, and at a reasonable profit.

Management must understand how to gain and retain the respect and confidence of the company's stockholders, who represent another large group of people. In the case of the Pennsylvania Railroad there are 143,000 of them.

Management must understand the art of raising new capital in large amounts because a railroad is never a finished project but is constantly growing, not necessarily in miles of line, but through the constant improvement of existing mileage and equipment. This requires the maintaining of proper relationships with the investing public.

Management must also be capable of dealing successfully with the problems of governmental regulation of the railroads, now exercised almost exclusively by the Federal Government, through the Interstate Commerce Commission, and resting ultimately upon the intricacies of our vast political system—another great domain of complex human relationships.

Wherever we turn in the field of railroad operation and management the story is the same. The most exacting demands today upon the intelligence and foresight of management arise, not from technical, but from human problems and questions. This has come about as a process of evolution.

Mr. Lee, as a Vice-President of the Pennsylvania Railroad, is a recognized authority on railroad management and its problems. As a Technology graduate he is a loyal and interested alumnus, recently having been the only nominee for the office of President of the M. I. T. Alumni Association. We are very fortunate in having an authoritative article by such an outstanding Technology graduate.

The history of American railroading, now almost one hundred years old, is a story of astounding growth and development. After feeble beginnings, handicapped by skepticism and insufficient capital, our railroads eventually emerged triumphant in a contest, against heavy odds, to bring the widely separated boundaries of the country ever closer together. No other nation has had such need for railroads or has built so many of them.

The first sixty years in the life of American railroads were a period of experiment, invention, pioneering, promotion, and speculation, further marked by extremely rapid changes and unprecedented growth. As the last century drew to a close, however, railroad plant and equipment attained largely their present form and character. The basic inventions had proved their worth. The railroad map had assumed an aspect differing little from that of today. The industry as a whole was beginning to reach stability, and railroad operation was crystallizing into a highly standardized body of practices and principles. Governmental regulation was coming into play; unrestricted competition was ending.

Railroad progress since that time has chiefly centered upon the more intensive development and improvement, and more efficient use of established lines, rather than upon extensions into new territory or the adoption of radically different principles. It is important to note, however, that this period of intensive development has required the raising of more new capital by far than went into the construction of the original lines all put together.

Governmental regulation, in its earlier stages, was frequently marked by policies which spelled "starvation" for the railroads. Rates were kept unduly low, credit was impaired to such an extent that progress was seriously handicapped, and the railroads were unable to keep pace with the traffic demands and needs of our rapidly growing country. Still suffering from the hampering effects of such policies, the railroads were called upon to face the emergency burdens imposed by the war, which finally culminated in the period of temporary Federal control, ending March 1, 1920.

(Continued on page 84)

NEW UNION STATION, CHICAGO, ILLINOIS

X-Rays and the Ultimate Structure of Metals

An account of recent research in the Research Laboratory of Applied Chemistry considering metals as crystalline aggregates, which diffract X-rays in ways characteristic of their properties

By R. H. ABORN, '20
and
E. W. BRUGMANN, '24
Research Assistants, X-Ray Division, Research Laboratory of Applied Chemistry, Massachusetts Institute of Technology

Introduction

FROM the time of their discovery, metals have proved indispensable to civilization. Yet it is only within the last hundred years that their extraction, refining, and fabrication have ceased to be arts and have been the objects of scientific study. Since the art has so far exceeded the science, the latter is in a unique and difficult position, and must classify, correlate, and interpret a vast heritage of experience and, as well, point the way to future development.

This science has its foundations in the constitution of metals, which is in essence crystalline. That metal crystals do not always present regular external form, plane faces, and definite angles leads us to recognize two types of crystallinity: (1) gross crystallinity, which has to do with whole or aggregates of crystal grains; and (2) ultimate crystallinity, which has to do with the regular atomic arrangement within the individual crystal grains. To illustrate, consider the process of etching. A polished and lightly etched piece of metal (3 per cent Si steel, for example) appears under the microscope as a mass of polyhedral grains. Further etching develops the crystalline character of the individual grains by producing distinct differences in color from grain to grain, while deeper etching produces geometrical figures having the same form and orientation within any given grain. Thus the piece of metal is composed of an aggregate of gross crystal grains, and each grain has a definite crystalline structure.

Ultimate Structure

The ultimate structure of each crystal grain consists of atoms arranged in space in a definite geometrical pattern out to the crystal boundaries. The series of points representing the atom centers forms a space lattice, which is built up of a unit repeated indefinitely in space. The order of magnitude of the atom spacing is about one-hundred-millionth of an inch. In comparison with microscopic visibility, it is as if we were examining a map of the coast line of America and by an extraordinary magnification could see the waves themselves.

Of course it is beyond our power to make such a microscope, but we can study and quantitatively determine the atomic arrangement in crystals by means of X-rays.

X-Ray Diffraction by Crystals

Laue discovered in 1912 that, analogous to the diffraction of light by a line grating, the regular arrangement of

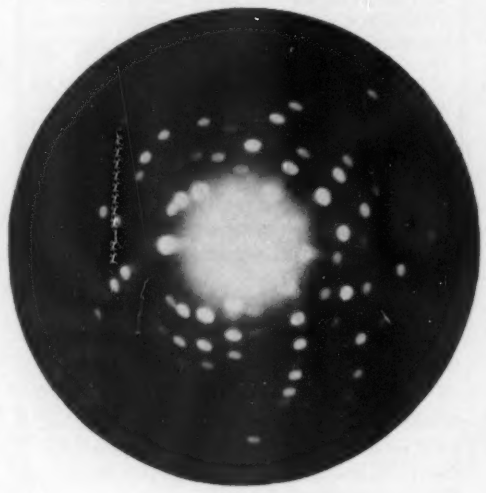


FIGURE 1
Pinhole or Laue diagram of 3 per cent Si steel.

atoms in crystals formed a compound grating sufficiently fine to diffract X-rays. Two years later Bragg derived the law of X-ray diffraction

$$\lambda = 2d \sin\ominus$$

where λ is the wavelength of the

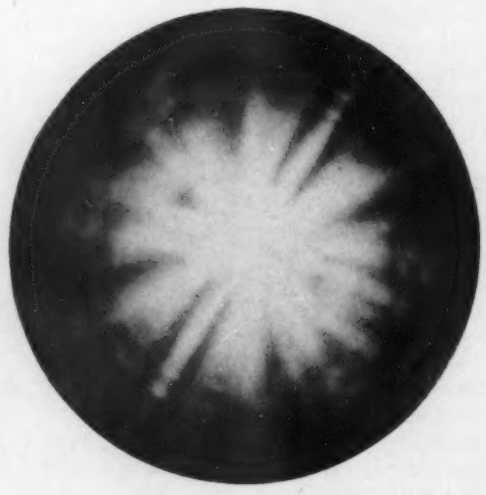


FIGURE 2
Asbestos fiber (tremolite) placed normal to the beam, showing that it is composed of minute, parallel, needle-like crystals. A case of natural fibering. (Fiber axis horizontal.)

X-ray (about 1/6000 the wavelength of sodium yellow light), $\ominus$ the angle of incidence or reflection, and d the actual spacing of the planes of atoms in the crystal lattice. X-ray diffraction effects are usually recorded photographically, although ionization chamber-quadrant electrometer measurements are an alternative.

Apparatus

An apparatus used in the X-ray Division of the Research Laboratory of Applied Chemistry consists of a steel lead-lined cylinder containing a Coolidge water-cooled molybdenum target X-ray tube operating at 30,000 volts, placed co-axially. Eighteen apertures in the steel cylinder enable as many diffraction line spectrum and pinhole pictures to be taken simultaneously.

Diffraction Line Spectrum Method

The chief field for diffraction line spectrum methods is in the identification of constituents. Thus, whether two alloyed metals are present in a mechanical mixture, in solid solution, or in definite intermetallic compound can be told by this method. The photographic film is placed in a holder or cassette on the arc of a circle at whose center is the sample. The cassette is then adjusted on the apparatus with the specimen edge in the direct X-ray beam.

Lattice Types in Metals

The lattice type and atomic spacing as determined by the diffraction line spectrum method vary from element to element. It is found, however, that most common metals crystallize in three simple lattice types.

The more ductile metals, such as gold, silver, copper, and aluminum, belong to the face-centered cubic lattice type in which the unit is a cube with an atom at each corner and one at the center of each cube face. Less ductile metals, such as molybdenum, tungsten, and chromium, belong to the body-centered lattice type, in which the face-centered atoms of the unit cube are replaced by a single atom at the cube center.

The element iron crystallizes in the body-centered lattice at room temperature and has a face-centered cubic allotropic modification above 900° C. The third common lattice type is the hexagonal, in which such elements as zinc, magnesium, and cadmium crystallize.

Every lattice gives its own characteristic lines on the diffraction film. It serves, then, as a valuable tool to study allotropy, alloys, solid solution, coring, intermetallic compounds, and in heat-treated steel the constituents martensite, troostite, and sorbite. These latter have no characteristic lattices so far as is known, yet they effect decided changes in the iron and carbide lattices of steel.

FIGURE 3

Medium carbon steel as cast — showing large crystals, preferred orientation, and internal strain.

Pinhole Method

Pinhole photographs are made by direct transmission of a fine pencil of X-rays through the sample. The diffraction effects are recorded on a film placed normal to the beam, which registers as the central spot in each picture. It should be understood that the pinhole method gives one type of information, which is practically of most importance. Except in a few cases it does not disclose the fact that in ordinary steel the iron atoms are arranged in a body-centered cubic lattice whose facial planes are 2.86×10^{-8} cm. apart. Such information as this is best obtained by the diffraction line spectrum method or by spectrometric measurements. On the other hand, the monochromatic pinhole method discloses the fact that a whole series of specimens with the same fundamental iron lattice may show vastly different properties, because they have been worked or heat-treated differently.

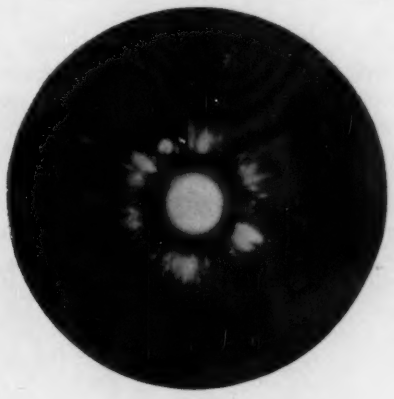


FIGURE 4

Same as Figure 3, after standard commercial anneal. Crystal structure partially refined, but still indicates considerable directed orientation and internal strain.

There are four general types of information obtainable from pinhole pictures:

(1) Approximate absolute crystal size.

(2) Exact arrangement of atoms in the crystals.

(3) Random arrangement or a preferred orientation of crystals.

(4) Presence of internal strains.

Crystal Size

If the crystals are sufficiently large so that the X-ray beam passes through only one, a diagram such as is shown in Figure 1 is obtained. Since the beam was unfiltered it contained a range of wavelengths and the picture is equivalent to a Laue diagram. This was a sample of 3 per cent silicon steel, critically strained and subsequently annealed to produce the phenomenon known as Stead's brittleness.

For a given volume of metal penetrated, the number of the diffraction spots is directly proportional, while their size is inversely proportional to the number of crystal grains contained in that volume. It should be added that the proportionality is not exact, but the tendency lies strongly in these directions.

We therefore have a criterion of absolute crystal size (for a grain may comprise more than one crystal), as distinguished from apparent crystal size as observed under the microscope. Furthermore, heat or mechanical treatment, under certain conditions, may completely mask any microscopic evidence of grain boundaries, but cannot at all interfere with the X-ray determination, since the latter depends neither on polishing nor etching, and penetrates the very heart of the structure.

As the crystal size becomes smaller and smaller through the agency of heat treatment or preferably mechanical working, or both, the diffraction spots gradually merge together. When a monochromatic beam is used, the spots tend to fall on concentric circles, giving thereby the second type of information, i.e., the exact arrangement of atoms in the crystals, and the type and dimensions of the space lattice.

FIGURE 5

Ideal structure of annealed steel casting — small equi-axed crystals, with neither directed orientation nor internal strain.

It is true that an expression has been derived, and under certain conditions is satisfactory, for determining crystal size from the width of the diffraction line spectra, but the pinhole diagrams are much more sensitive to changes throughout the full range of crystal size, and practical results are more quickly obtained.

Fibering Effects

To illustrate simply the mechanism and effects of crystal orientation a pinhole diagram of fibrous tremolite (one type of asbestos) is shown in Figure 2.

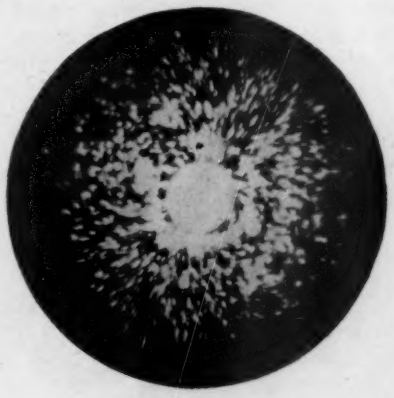


FIGURE 6

Electrolytic lead deposited from fluoborate solution — no gelatine.

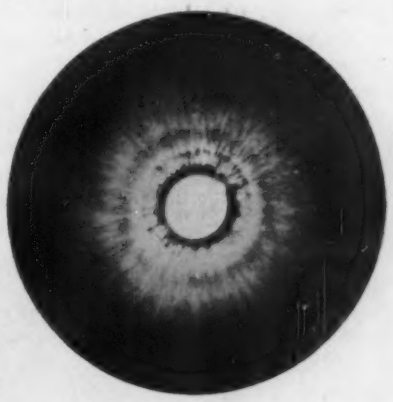


FIGURE 7

Same as Figure 6 except that gelatine was present in the electrolyte. Note the great diminution in crystal size, as well as presence of internal strains, in comparison with Figure 6.

Visual examination shows that in this mineral the crystals exist in minute, needle-like, parallel groups, each mi-

(*Continued on page 76*)

Foreign Telephone Systems

The present extent and growth of telephone engineering in the foreign countries

By JOHN J. PARSONS, '24
Traffic Department, Cuban Telephone Company

OF those developments now under way in the field of communications, none is of greater interest, or charged with a profounder significance to future international relationships, than the progress which many countries are making in the extension and improvement of their telephone systems. It is just fifty years since the telephone was invented. Today there are more than 24,500,000 telephones in all parts of the world, and wherever they have come into general use it is difficult to form a picture of what business and social life would be like without them. And so in these days, when various nations are striving for a fuller realization of their capacities, they have fixed upon the telephone as a powerful aid to their industrial and commercial enterprises.

In the very van of these countries is the Republic of Cuba, which not only has a thoroughly modern telephone system, but one also which excites the admiration and envy of every telephone engineer who studies the manner of its development.

There we find that automatic exchanges have been installed in all the larger cities and towns. Furthermore, the Cuban telephone system is in a distinctly advantageous position in that it has grown up with automatic equipment, instead of finding itself obliged to abandon a large amount of manual equipment in order to install the automatic. If the telephones of a town are converted to automatic while they are still relatively few in number, the derangement to service, and the cost to the company are small, and subsequent growth is easily taken care of by successive small additions. This is in decided contrast to the situation in the larger cities of the United States, where the operating companies are faced with the problem of converting an extensive and complicated system, with the accompanying annoyance to subscribers and tremendous outlay for the company.

The Cuban Telephone Company obtained its concession from the Cuban Government in 1909, and took over most of the independent systems which were then in operation. Since that time it has progressively taken over the remaining independent systems, so that at the present time the entire long-distance service, and also the local service of practically all communities having phones, are under a central management.

BRINGING THE SUBMARINE CABLE ASHORE AT ALGECIRAS, SPAIN

The Strowger Automatic System of local service was put in operation in Havana in 1910, and has now grown to over 40,000 connected subscribers' phones, representing a "saturation" of 7.75 telephones per 100 inhabitants, a ratio which is the highest of any Latin American city, and which compares favorably with saturation figures in the United States.

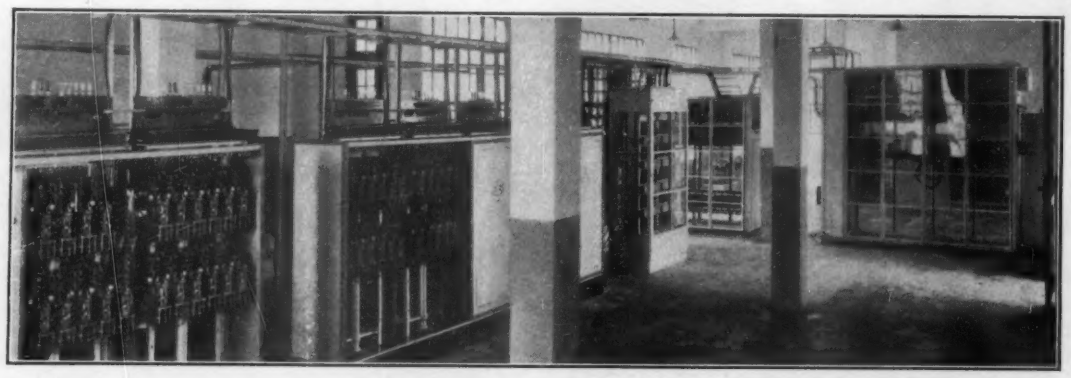
The Cuban Telephone Company has also followed the policy of installing automatic equipment in every city where the number of subscribers has expanded to a point warranting such installation. Such is the popularity of the automatic telephone with the Cuban public that the opening of an automatic exchange is usually accompanied by an increase of from 25 to 50 per cent in the number of subscribers to the service.

Approximately 84 per cent of all the telephones in Cuba are automatic. The remainder are connected to party lines in rural districts, or to small manual magneto exchanges in places not yet large enough to justify the installation of an automatic exchange. There are, altogether, over eighty communities in Cuba having local telephone service. These are all interconnected by a carefully planned and soundly constructed system of long-distance lines, and the entire network is connected with the system of the American Telephone and Telegraph Company by the submarine cables from Havana to Key West.

These cables, three in number, were put into service in April, 1921, the inauguration ceremonies including the successful establishing of a connection between Havana and Santa Catalina Island, off the Coast of California. This connection, about 5500 miles in length, was, and still remains, the longest ever established; and the eminent success of the test testifies to the remarkable advance achieved in the art of telephony in the short period since its inception.

The International Telephone and Telegraph Corporation was organized in 1919. Since that time the scope of its activities has widened to a remarkable extent. It is now an organization —part "holding company" and part "operating company"—which affords technical and financial assistance in the development of existing concessionary systems, and fosters the organization of national companies operating in countries in which the Government has transferred its control to private enterprise. Its purpose, in any country in which it may become interested, is to develop a truly national system operated by the nationals of that country. This has already been done in Cuba and Porto Rico and is under way in Mexico.

(*Continued on page 88*)



THE NEW AUTOMATIC CENTRAL OFFICE AT CAMAGUEY, CUBA

Metalclad Rigid Airship Development

An extract from Mr. Upson's paper to the Society of Automotive Engineers, especially prepared for T. E. N.

By RALPH H. UPSON
Chief Engineer of Aircraft Development Corporation, Detroit, Michigan

A BRIEF account of the accomplishments of present-day airships, with a statement of their known faults and their present limitations, indicates that until there is a radical change in design further advancement will be slight.

In 1897 an Austrian named Schwartz designed a sheet aluminum airship, the construction of which was actually finished after his death. It was inflated by fabric gas-cells and got into the air, but it could not be operated, due to serious faults in the structure, power plant, and controls.

Zeppelin's first metal-framed airship was also a failure, but his genius and perseverance won out in the end, and the duralumin-framed Zeppelin became the world's standard in airship construction. In a way it had too much success for the good of airship development generally, for, although the Zeppelin itself was greatly improved by refinements of design and construction, it naturally discouraged further radical changes, especially during the War. Since the War, however, the very attractive possibilities of metal construction have proved irresistible.

Already the all-metal airplane is a practical reality, being made from the same duralumin that had previously been developed for the framing of airships. The success of the all-metal airplane is now in turn a great stimulus toward the elimination of dry goods as a covering for airships. The solution of this problem has involved a combination of:

(1) Inquiry into the general feasibility of the project.

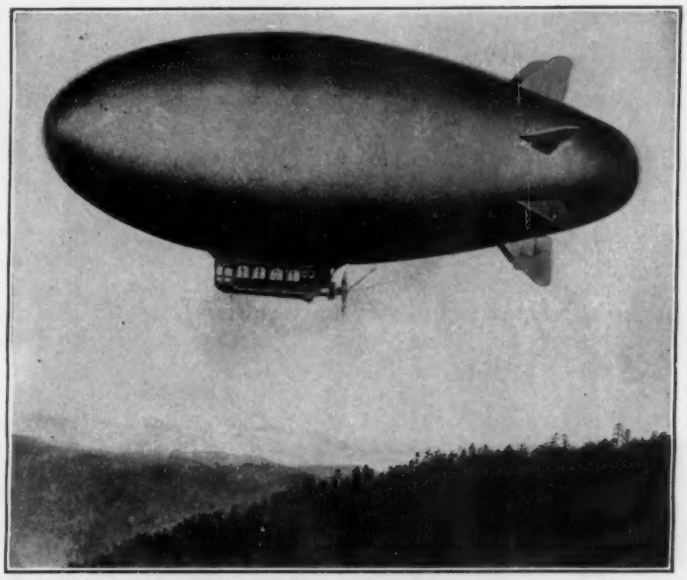
(2) Search of materials and methods already available.

(3) Invention and development of means to fill the new requirements.

(4) Detailed calculation and experiment to establish a sound design.

(5) Similar research as to means of practical production.

Five years, representing about thirty man-years, have been spent on this program, which is now practically finished. The general feasibility of the Metalclad airship has been mathematically and experimentally proved. Sheet duralumin in quality now available proves immensely superior to fabric in almost every respect. Means have been devised for utilizing to full advantage the fundamentally superior qualities of the material. The stresses and aerodynamic characteristics have been most carefully studied for a great variety of operating conditions, showing a strength, stability, and general efficiency greater than any previous airship. Production methods and equipment in themselves have involved considerable new development to suit the requirements of the design. Successful research indicates that Metalclad airships, with all their other advantages, can ultimately be built more cheaply than the fabric-covered type.



S. A. E. Journal

THE APPEARANCE OF THE MC-2 WHEN COMPLETED

It seems very chunky, but wind-tunnel tests have shown this shape to be much more efficient than that of the Los Angeles or Shenandoah.

The first design to be laid out with any attempt at completeness was for a ship of 1,600,000 cubic feet, which is shown in the accompanying picture. When this size was chosen it was with the idea that it was about the smallest Metalclad unit which could be made a practical success, the original thought being that some sacrifice in lift would have to be made to gain the practical advantages of metal construction. The first big surprise came with the weight statement of this ship, which showed an actual reduction in the total weight compared to fabric construction, with a strength and over-all efficiency substantially better than the somewhat larger Shenandoah.

The assumed duralumin plating weighed approximately four times more per square foot than the fabric cover of the Shenandoah. Yet the total weight was less! The result was due largely to the manner in which the single metal surface was made to serve a number of different purposes, made possible by the homogenous character of the structure.

Considered as a cover, the metal serves the same purposes as the fabric outer cover, but does it more efficiently by eliminating the flapping and moisture absorption so common to fabric. That is, however, only the beginning. In the Metalclad ship the surface plating also holds the gas and, in combination with the frame members, carries most of the stresses. The general principle of construction is similar to that of a steamship, in which the frame and plating are neither of them structurally self-sufficient, but each supports and reinforces the other. Thus the present design is far more than and essentially different from a mere metal-*covered* airship.

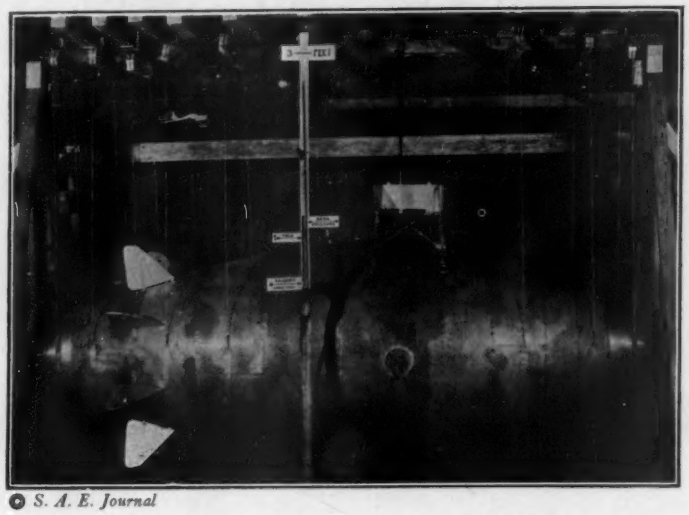
This saving in weight, made possible by the unit structure and by refinements in design, in turn brought up the question as to whether we could not produce a still smaller size ship for demonstration purposes. Study in this direction has finally crystallized into a size of only 200,000 cubic foot volume, about one-tenth that of the Shenandoah, and smaller than has been attempted before for any rigid airship. This demonstration unit, which is illustrated in the accompanying drawing, and is designated the MC-2, will have a better performance in most respects than that of a non-rigid airship or "blimp" of similar size. Thus although too small for economic commercial service, this ship will have characteristics of great value for scouting, training, and other special purposes. Tentative designs and performance calculations have also been made for ships of 80,000, 500,000, 1,200,000, and 5,000,000 cubic feet respectively. But reports recently appearing in the press of the alleged *completion* of plans for the last-named size are, to say the least, greatly exaggerated. The 200,000

cubic foot size is the only one ready for immediate construction. In many respects this small size will present more conclusive demonstration of the Metalclad principle than could a larger unit in which the weight consideration would not be so serious.

A non-rigid hull tends to assume a shape distorted from the true circular shape, thereby reducing the fabric stresses. Such distortion would be fatal in a metal shell, but in this case, because of its rigidity, it can be built to the proper shape from the start. The shape is then independent of the internal pressure, and all stresses in the metal covering are simple tensile stresses with no tendency to buckle. However, it is advisable to maintain a slight pressure inside to reduce vibration, and this is met by placing air scoops under the nose in the proper position so that at all speeds the air flow at the scoops is proportioned to give the proper internal pressure. But if at any time, such as handling on the ground under high winds, a greater strength is needed, this can be accomplished by putting a relatively high pressure in the hull, which will stiffen it considerably.

A further investigation of the aerodynamical properties of airships revealed that pressures due to motion through the air on the outside of the envelope were greater than atmospheric at the nose, less than atmospheric over most of the length along the side, and arose to positive values at the tail because of the "sucking in" effect there. For an object such as an airship hull it was found that the total resistance was only slightly larger than the skin resistance, indicating that the impact resistance was very low. This finding led to the design of a new-type hull.

Formerly it was thought that an airship had to be long and slim to go through the air easily and have proper stability. Directly or indirectly, this false assumption has been the guiding hand of airship construction for a quarter-century. Count Zeppelin based his design on it. The semi-rigid airship was created for it. The non-rigid airship was greatly complicated by it. Throughout all these years the airship has struggled with the veritable Old Man of the Sea on its back. Even now, most engineers are only beginning to see that what success the airship has had has been in spite of this false god, who has claimed such heavy tribute in the wreckage of ships and lives. Wholly aside from their application to Metalclad construction, the improved aerodynamic and structural characteristics of the short hull, here described, are of fundamental importance.



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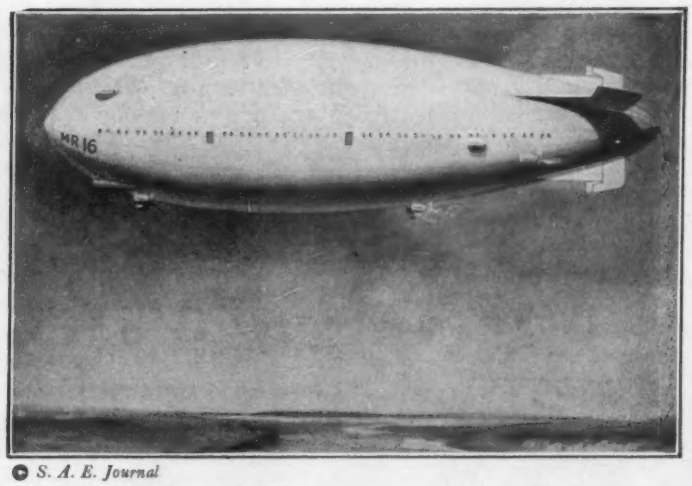
WATER-MODEL HULL OF THE MC-2

It is built 1/14 full size, weighs 51 pounds, and holds 2½ tons of water, which overloads it to five times the normal condition.

For the Metalclad ship, good structural efficiency requires a fairly short and compact hull. We approached the problem confident that with the proper curves such a shape could be made efficient. The results are rather surprising. According to the best evidence available, the Navy wind tunnel, our new hull form has a lower resistance for equal volume than any shape hitherto produced. This is for a length diameter or fineness ratio of only 2.8 to 1.0 compared with 7.2 to 1.0 for the most recent Los Angeles and 8.6 to 1.0 for the Shenandoah.



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METALCLAD AIRSHIP OF 1,600,000 CUBIC FEET CAPACITY

The passenger cabins are inside the main hull, on the two sides. The ship would weigh less than with fabric construction, and show better strength and efficiency than the Shenandoah.

The improvement in aerodynamic stability is even more striking. With our new fin arrangement totaling 17 per cent less area than the Shenandoah surfaces, for equal volumes, the stability and control are more than twice as good, and studies now under way give promise of still better results. This almost revolutionary improvement is largely due to the detail of the fin arrangement in which a greater number of small units, in this case eight, is used, instead of the four that became conventional about ten years ago. The static stability of the MC-2 is somewhat excessive, but the larger Metalclad units with distributed loads and our internal corridors can be made about right. The aerodynamic lift is almost double that of the Shenandoah for equal volumes.

The next problem was to find some way of running an overload test on the hull itself. Even if desired, this could not be done on the full-size ship because its lift is strictly limited by its gas content and aerodynamic properties. Many tests had, of course, been made on individual girders, plating, and fittings, but a practical demonstration was also wanted of the structure as a whole. This was done by a hydrostatic or "water model."

To go into the general theory of an airship water-model is not necessary*. The reduced-scale model is simply hung upside down and filled with water whose weight acts in reverse proportion to the gas lift in the full-size ship, other forces being also applied in proper proportion. The usual scale of a water-model is the "natural" one of 1/30 the linear dimensions. This produces surface stresses just equal to those in the full-size ship. If the model is built to a larger scale than 1/30, using the same surface materials, it corresponds to overloading it, as if it were filled with a heavier fluid. For the metal water-model a size of 1/14 was chosen, which, when inflated to a corresponding pressure-head, is equivalent to overloading the full-size ship about five times and subjecting it to a pressure sixty-five times as great.

This is so severe that the effect of surface stiffness of the material is practically eliminated. In addition, the frame was reduced to the minimum

*See TECH ENGINEERING NEWS, Vol. VI, No. 3.

and made relatively more flexible than in the full-size ship. In figures, the water-model hull, including its internal structure, weighs 51 pounds and holds over 2½ tons of water. It has not only the strength to carry this large overload, but is rigid under all conditions, including arbitrarily applied bending-moments that are far greater than any which could be expected in flight. In general the water-model results checked so closely with the calculated stress values that for future units it will probably be unnecessary to make water-model tests.

A technical discussion of the calculation of the reserve strength in the hull reveals that an actual safety factor of three is produced under the analysis of ten different conditions of loading. Because of the chunky form to be used, the shearing, bending, and torsional stresses per unit volume are very greatly reduced, reduced so far that the possibility of breaking in the air, as did the Shenandoah, is not a factor to be considered. The transverse stress due to direct pressure would be in excess of the longitudinal stress that wrecked the Shenandoah.

An investigation of the regulation of the pressure control reveals that the problem becomes simply the mathematical calculation of the proper diameter to be used on the outlet valves.

The hull is entirely of metal except for an internal fabric diaphragm separating the balloonet or air-compartment from the gas above. This diaphragm yields with varying proportions of gas and air in the same way as the bottom portion of the gas cells in a conventional rigid airship. In the MC-2, however, the balloonet diaphragm will normally be kept flat down against the bottom of the hull, in effect making a metal container of the entire hull throughout the greater part of which the gas is in direct contact with the metal. This highly desirable arrangement naturally depends upon having a reasonably gas-tight surface.

Early encouragement of the possibility of gas-tight seams in duralumin sheet was had by analogy with steel gasometers that are much tighter and more satisfactory than any made of fabric. Many different types of seam were tried without success. However, it was apparent that if the same rivet spacing and other dimensions as used in gasometer practice could be reduced in proportion to the thickness of sheet, the results should be comparable. The big trouble was the enormous number of tiny rivets, which is about 3,000,000 in the small MC-2, that would be required. This problem has been solved by our successful development of a special riveting machine that automatically puts in more than 5000 rivets per hour, and does it much better than would be possible by hand.

The only thing that we did not have in the duralumin seam was the rust that works into the seams of a steel gasometer and plays an important part in making it tight. This is supplied to our seams independently by a specially prepared seam dope. Again we attain rather surprising results. Tests have averaged less than one-tenth the leakage usually specified for goldbeater-skin fabric. This includes results throughout an extreme range of temperature and after very pronounced vibration, although experiments at the Bureau of Standards indicate practically no vibration from aerodynamic causes. The strength of our standard seam is greater than the yield-point of the material.

The material itself is a development of the duralumin manufacturers, who have co-operated in a very fine way to render their product available in the form needed. The art of rolling a very long and wide fine-gage duralumin sheet that is unusually flat for the tempered condition, and with the gage closely controlled, is a peculiarly American work of the last three years, and beyond anything that has been done in Germany, England, or France. Duralumin, although much less corrosive than steel, still needs a protective coating for the best results; and we have found an extremely light and efficient preparation for the purpose.

The patterning of the surface follows the same general principles as with fabric, but special equipment had to be devised to take care of the greater accuracy required. The internal frame-members are simple in form, but have involved practical difficulties of shaping to the exact curve and angle.

On account of its small volume, which is about equal to one of the gas cells in the Los Angeles, the MC-2 will have only a single gas compartment, and a single outside-hung car as shown in the diagram. Larger Metalclad units will have compartments divided by partitions that will bulge in the direction of the pressure difference. They will also have most of the useful load carried in either internal or external corridors that are located preferably one on each side. The construction also lends itself admirably to the use of engines housed within the hull. It is expected to erect the hull in a vertical position, the small ones as a whole, the larger ones in two or more sections corresponding to the compartments in the completed ship. This

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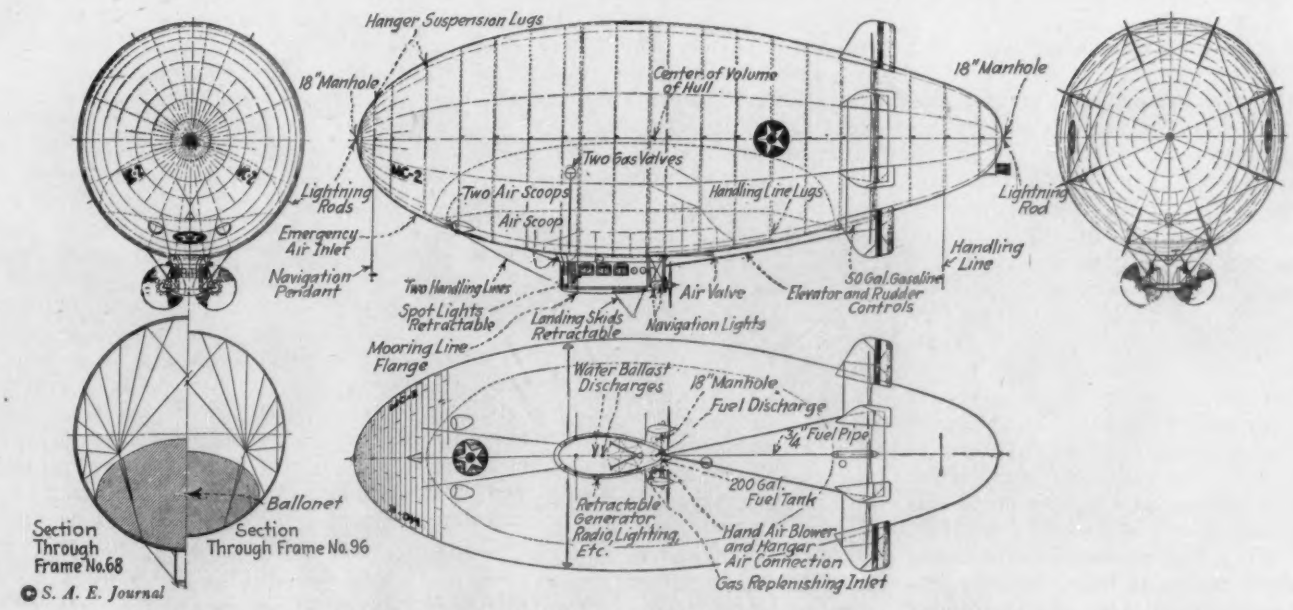


DRAWINGS FOR 200,000 CUBIC FOOT METALCLAD AIRSHIP

The MC-2 is the smallest rigid airship ever attempted, and is to be constructed for demonstration and test purposes.

The Application of Electricity to Railroads

The fundamental questions of electrification as the engineer meets them

By ARTHUR J. MANSON, '05
Manager, Heavy Traction Division, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania

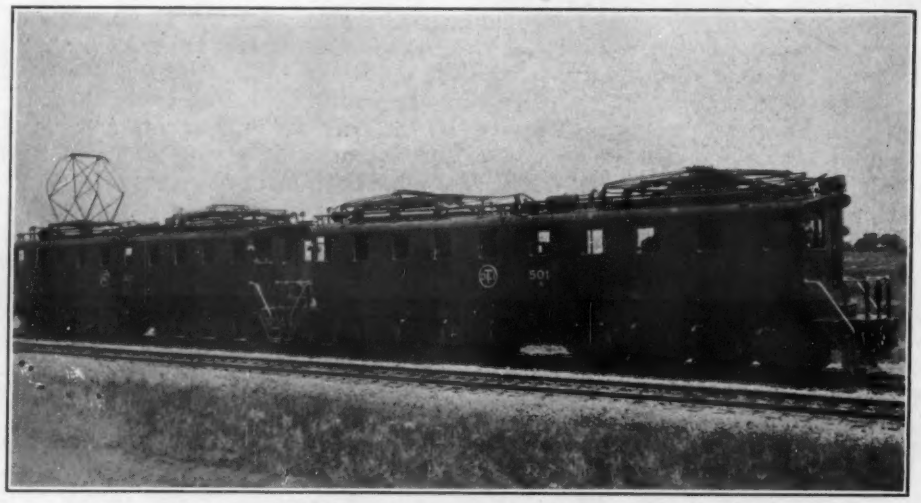
IN normal business activity the railroads of the United States carry daily approximately three and one-half million tons of freight, with an estimated value of these commodities in transit every day amounting to several hundred million dollars. We are a nation of great distances. Our very existence depends upon transportation. By this means we are able to raise corn, wheat, and other farm products where they can be raised at the lowest cost and we can manufacture products under the most ideal conditions, the railroads supplying the means of transportation to the congested sections of population. It is easily seen that transportation is, therefore, a big factor in our daily life, and that the economic growth of our country depends on this transportation.

We are living in the age of electricity. We have seen this great force applied to various manufacturing industries, for instance, where the electric motor and individual drive have replaced the reciprocating engine and extensive shafting, and the complete electrification of the steel rolling mill — in each case the work being done not only cheaper but better, and with greater dispatch and with increasing capacity.

Rail transportation is not standing still. Our population is rapidly increasing, our cities are growing bigger, and the population is becoming dense in the surrounding suburbs. We are living better than we ever lived before, and are enjoying luxuries never dreamed of by our fathers, so that the railroads are approaching congestion in many sections of the country and are confronted with the lack of track and terminal facilities to meet this ever-increasing rate of tonnage.

The railroads have been one of the last great industries to make the most effective use of this great power—electricity. The railroads must make major improvements to eliminate this congestion which is already here, and be in a position to handle effectively this duty which is being rapidly imposed upon them. One of these major improvements is electrification, a transportation tool which if applied and used correctly will give the most satisfactory results.

There are thousands of miles of railroads in the United States, and a large percentage of this mileage will have no need for electrification for years to come. Electric operation cannot compete economically with steam operation in every case. Conditions must be suitable to give a return either on the capital invested or in better service eliminating congested sections to warrant electrification.



THE FIRST MOTOR GENERATOR TYPE OF LOCOMOTIVE IN THE U.S.
The 22,000 volt current overhead is used to run motor generators supplying 600 volts direct current to the driving motors.

We are going to see electrification on the congested sections over which traffic is approaching the limits of the present facilities, which may be due to a single-track road having physical limitations for improvements involving great expenditures; or due to a heavy mountain grade where maximum daily capacity is a resultant of low operating speeds; in congested trunk-line service with its large number of high-speed trains, both passenger and freight; in freight and hump yard service; and in terminals which have reached their capacity due to the great suburban growth.

The electric locomotive has inherent characteristics which make it particularly attractive for handling transportation. Being a converter of power, and not a self-contained unit, the electric locomotive has the ability to take advantage of extra adhesion which may be due to natural causes or to the sanding of the rails. Unlimited power is available for use of the electric motors, so that high tractive efforts for short periods of time can be obtained. Steam locomotives for any operating division are rated in terms of tons trailing load, depending upon the profile over which the class of steam locomotive is operating. During the winter months, this tonnage is decreased by a percentage depending upon the temperature. While the electric locomotive has a continuous rating, in applying the load to the electric locomotive a maximum grade on the division may not govern the tonnage as sufficient tractive effort can be exerted to take the train over this grade. The only point to be considered is that the time of the excess load will not overheat the motors and that the temperature after completing the run is not above the continuous rating of the motor. This factor makes it possible to give an electric locomotive a tonnage rating higher in proportion to its weight on drivers than would be possible for the steam locomotive operating over the same profile.

While the railroad man is interested in an engine's ability to handle trailing load, it is the speed at which the load can be handled which is the important factor. Horsepower is the product of the tractive effort and the speed; it is the direct measure of the locomotive's capacity to work; it is a measure of the hourly ton miles that can be handled over any division. With electric locomotives it is possible to obtain high horsepower and maintain the maximum starting tractive effort up to speeds two or three times that possible with the steam locomotive.

The serviceability factor is one of the greatest of the inherent qualities which the electric locomotive possesses. It means availability to give service hour after hour and day after day. It means that the locomotive is available something on the order of 6500 to 7000 revenue hours per year, or nearly 90 per cent of the total time, while the steam locomotive gives only about 3000 revenue hours of work, or only about 30 per cent of the time.

This high serviceability factor means

the ability to operate at a high daily mileage. Electric locomotives are making in excess of 100,000 miles per year, with individual locomotives operating as many as 12,000 miles per month, and occasionally 900 miles in twenty-four continuous hours. In switching service, electric locomotives make over 4000 miles per month, being in service twenty-four hours per day, utilizing three eight-hour crew shifts, and in continuous service this length of time for thirty continuous days.

The design of the electric locomotive is not handicapped by fixed mechanical conditions. When axle loadings reach limits for a section of track or bridges along the right-of-way, additional axles can be easily added and desired tractive effort easily obtained. Moreover, electric locomotives can be operated in multiple with one crew. Where very powerful units are desired the complete locomotive can be split into articulated motive power units and almost any tractive effort within reason obtained.

Another characteristic is its ability to utilize the energy available when the train is running down grade for regeneration of power. The energy which generally is dissipated as heat in the brake shoes is utilized to deliver this energy back into the electrical conductor and thereby help supply power to the other trains.

The operating characteristics of the electric locomotive are not fixed and similar for all types, but very greatly depending on the type of the electric motor and on the system utilized. We have the varying speed locomotive utilizing the series motor, whereby under severe torque requirements the speed is low, and as the tractive effort is reduced the speed increases, making the locomotive automatically self-adjusting for load conditions, the speed tractive effort curve following somewhat that of the steam locomotive. In addition, we have the electric locomotive of the constant speed type, utilizing three-phase motors. If the electric locomotive has accelerated the train to a definite speed, say fourteen miles per hour, then the locomotive maintains the speed up hill and down hill regardless of the grades or curves. For certain operation, such as excessively heavy-duty mountainous freight service, this speed characteristic may be ideal.

Comparatively recently a new type of locomotive has been developed for operation from the single-phase high-voltage trolley. Credit can be given to Henry Ford, who, in conjunction with the Westinghouse Company, has developed, and now has operating, the first motor-generator locomotive in this country. Each locomotive consists of two motive-power units operating in multiple. The equipment of each motive-power unit consists of a transformer, a direct-current generator driven by a single-phase motor, eight axle-hung direct-current series type traction motors, together with the necessary control and auxiliary apparatus. At the present time single-phase power at 11,000 volts is collected from an overhead system by means of a pantagraph, although the equipment is laid out for ultimate operation with 22,000 volts on the overhead wire. Direct current for driving the motors, all of which are connected permanently in parallel and having a rating of 225 H.P. at 600 volts, is delivered by the motor-generator set.

The motor-generator type of locomotive has certain operating characteristics and features which make it particularly adaptable for certain railroad applications. As with other types of alternating current locomotives, it utilizes single-phase alternating power supply for the trolley—a system particularly adapted for the transmission of power in bulk. Power companies, in order to meet power demands and to transmit large drafts of power economically to great distances, have gradually increased the transmission voltage. There is no situation where this condition of transmission of power in bulk is more emblematic than in the case of railroad operation. We are operating heavier and heavier trains, and electrification is going to make possible increased train weights rather than a reduction in weights. These increased weights, combined with the higher speeds possible, will mean greatly increased power requirements over that realized today.

Direct-current traction motors of the most rugged type are used. The control apparatus is of the greatest simplicity and flexibility. In general, the well-known Ward-Leonard scheme of control is utilized, so that it is not only possible to obtain a large number of operating speeds, but the greatest smoothness of operation can result. With this type of voltage control there is a consequent freedom from rheostatic losses combined with low accelerating peak loads and the ability to operate continuously at any desired speed.

The speed characteristics of this locomotive are of particular advantage to railroad operation, especially where this type of locomotive may be used as pusher service to help out through steam operation on heavy grades, where it is

(*Continued on page 92*)

THE MOST POWERFUL LOCOMOTIVE IN THE WORLD

The electric freight locomotive as used on the mountain lines of the Virginian Railway.

Open-House Night

The plans for Technology's evening "at home"; what is to be seen and how

TO those not closely connected with the Massachusetts Institute of Technology, our life appears to be merely a monotonous round of everlasting delving into advance theories with little or no relief in the form of associations and recreations. The engineers who employ Tech men have found that we have a good practical knowledge as well as our theoretical learning, and have expressed surprise that we can acquire some of the facts we do while still in college. But even they know little of the campus activities in which we indulge and extend our undergraduate training. With these ideas in mind the Combined Professional Societies have decided to make changes in the accepted routine of the annual Open-House Night, which occurs this year on Thursday, April 22.

In addition to all the displays and demonstrations which have made the evening so great a success in former years, it is planned to increase the number of laboratories in operation, and especially to have a larger number of students actually at work on tests and theses, with the expectation that instead of being an exhibition of apparatus that is available it will be a demonstration of how our work is accomplished. The other innovation will be the throwing open of Walker Memorial and all the activity rooms so that our visitors may obtain an idea of our close associations, our active campus life, and those broadening influences that develop freshmen into men.

More invitations have been sent out this year than ever before. Over 7500 have been extended largely through the heads of the departments to members of engineering organizations and men who may employ Tech graduates in the particular line of work in which they are interested. As a result the attendance will consist of those who have a close interest in M. I. T., and not a passing curiosity, which has been evident among our visitors of the past. Many of these men are already familiar with the buildings, and the old system of traveling guides who escorted groups of the visitors from place to place has been abandoned in favor of stationary guides who will be thoroughly familiar with the apparatus and tests near their stations and who will direct visitors to the next point of interest. Col. F. W. Phisterer has agreed to supply most of his R. O. T. C. officers for this duty, and it is expected that so many will be in attendance that some may act as route guides if such a request is made. Every attempt will be made to enhance the beauty of the buildings. All interior lights will be lighted, and concealed searchlights will outline the dome and flanks of the buildings. The surrounding grounds will be flood lighted, and the simple beauty of Walker Memorial will be clearly revealed.

As the visitor enters the buildings he will be provided with a pamphlet describing the exhibits and their location. At the Main Lobby he will find the popular undergraduate orchestra, the "Tunesters," playing and will be met by additional guides with suggestions for the proper start of his tour of the buildings. In Building 4 he will find all of the lower class Chemical and Physical Laboratories active with students performing the routine experiments. On the first floor there will be an opportunity to witness advance work in inorganic chemistry and thesis work in the Chemical Engineering Department. In the basement experiments with very low temperatures in the Refrigeration Laboratory may be contrasted with exceedingly high temperatures on the second floor in the Heat Laboratory. Passing through the beautiful collection of geological prints on the corridor of the third floor the guest may see the mining and metallurgical engineers hard at work in Building 8 carrying on actual smelting and reducing of ores or making microphotographs of alloy metal surfaces. In the upper floors of Building 4 the corresponding advance work of the physicists may be observed in the Photoelasticity Laboratory where polarized light is used to observe the strains set up in celluloid models of complicated machine parts and structures. In the X-ray Laboratory a new industrial X-ray machine may be seen in operation within a room lined with eight tons of lead for protection.

Proceeding on into Building 10, the guest will do well to start his inspection with the extensive library on the top floor under the rotunda of the dome. On the fourth floor the Fisheries and Biology Laboratories will be open, as will the comfortable rooms for the faculty ladies and the co-eds on the floor below. On the second floor the largest lecture room equipped with the most modern devices for the demonstration of lecture experiments, will be in use. Demonstration desks for all manner of experiments are mounted on a small track and may be pushed in or out in a minimum of time between classes enabling set-ups for one class to be made while another class is still going on. The room is equipped with lantern slide and moving picture projectors, and the control of all lights, curtains, and ventilation is from a single board near the speaker's desk.

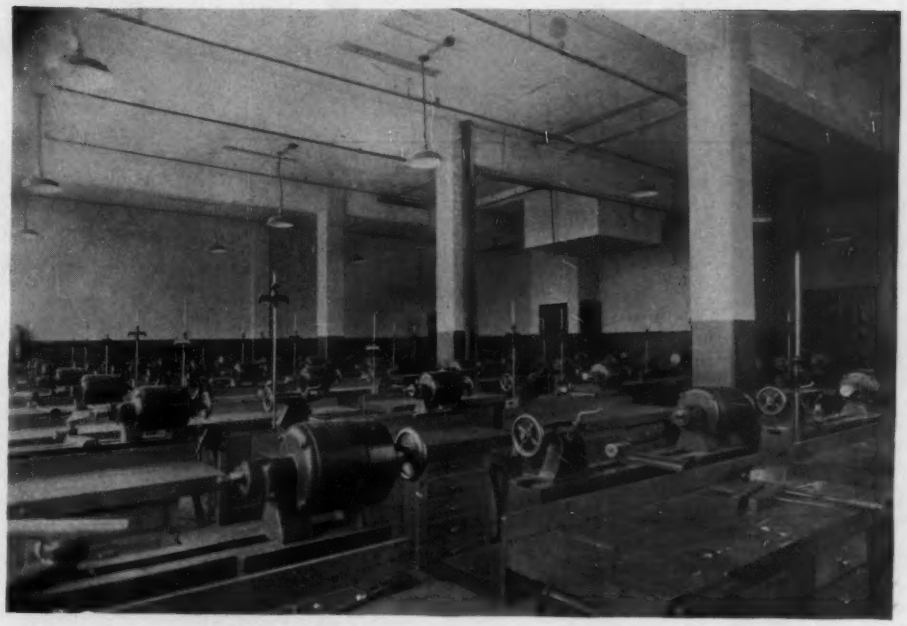
FOUNDRY LABORATORY

This laboratory can accommodate a class of 100 students, and is equipped for instruction in the principles and practice of hand and machine methods of quantity production.

During the evening motion pictures of the work conducted by the students in outside practice at Chemical Engineering plants and the General Electric Company will be shown. On the first and basement floors of this building are the large Electrical Laboratories equipped with the most modern dynamos and electrical measuring devices as well as many special machines for duplicating transmitting and manufacturing conditions. In this laboratory the student learns to test all kinds of commercial machinery and diagnose and remedy any ailments that may occur.

These rooms are adjacent to the Main Lobby, and after returning there for further instructions from the guides or by consulting his pamphlet, the guest may continue by the executive offices to the Steam and Hydraulic Laboratory, perhaps the most interesting of all because of the greater activity and large number of machines in motion. Here all types of steam engines and turbines will be in operation driving air-compressors and pumps. The largest of the steam engines drives a huge centrifugal pump which takes the water from the basement to the second floor at the rate of twenty-two thousand gallons a minute, where it is delivered into a channel for the study of hydraulic flows and weirs. At the end of this channel it flows into a large vertical turbine with a forty foot head. In the basement of this laboratory there are measuring tanks and many smaller set-ups for hydraulic tests and experiments. On the third floor of this building is the large Machine Tool Laboratory closely packed with all ultra-modern machines for the cutting of metals. Large lathes, grinding and planing machines will be in use capable of finishing machine parts to less than a thousandth of an inch. Accurate measuring devices capable of recording deflections of a millionth of an inch may be used by the visitors themselves. A novel device for testing the accuracy of ball-bearings by causing them to bounce from a smooth metal surface through a four-inch ring and then back into a hole of the same size will be on display. The walls of this room are lined with examples of fine machine work, and many complicated pieces of motors and machine parts are cross-sectioned and cut open for inspection. Adjoining this is the Textile Laboratory, and on the top floor are the extensive drafting rooms of the Mechanical Engineering Department.

Around an angle of the building are the Testing Material Laboratories, where all kinds of steel, rope, concrete, and other structural materials may be tested to destruction either by pulling, compressing, or twisting. The largest of these machines can exert a force of a million pounds, and actual destructive tests of girders and cables will be made. Around the next angle in Building 1 is a fine collection of photographs of the world's largest bridges and hydro-electric plants, many of which were designed and completed by Technology graduates.



PATTERN LABORATORY

Equipped with individual electrical units with a variable speed motor headstock. The control apparatus is built in, and all operating mechanism is entirely enclosed, giving a maximum safety factor.

The Pratt Building of Naval Architecture and Marine Engineering is next, and houses the large drafting and design rooms of the Naval Architects and the Aeronautical Engineers. M.I.T. has pioneered in the dissemination of aeronautical knowledge, and it can be safely said that no achievement of value has occurred in American aeronautics that has not been put through or aided by Tech men. The Institute is again pioneering in this field by the introduction next fall of a full four-year undergraduate course in Aeronautical Engineering. Designs completed by the students will be displayed on the drafting tables, and some of the work of the students of Architecture will be exhibited in this building. On the ground floor near the entrance is the Clark exhibit of marine models and prints containing representative half-models and plans for all typical boats and ships now in use, and a complete historical collection as well.

Proceeding outside to the detached laboratories the visitor will find the Aeronautical Laboratory directly behind the dome of the Main Buildings. It houses the two wind-tunnels, the largest of which is the largest wind-tunnel used by any educational institution in the world, having a throat diameter of seven and a half feet and being eighty feet long. Tests on propeller interference as described in the last issue of THE TECH ENGINEERING NEWS, and tests of complete models will be under way in both tunnels, the smaller of which has made notable contributions to aeronautical science. There will also be work proceeding on a sand loading test to determine the safety factor of a small airplane. Near this building is the Automotive Laboratory, where tests will be made on modern automobile and aviation engines, and where student ideas for new devices are tried out.

Just beyond, and next to the power house, is the Foundry Laboratory, where the complete process of casting and working metals is carried on. On the first floor is the forging room, where each student is provided with an individual forge, and will be working at shaping metal stocks or will be using the commercial drop-forging machine for the larger work. Upstairs in the Foundry Laboratory there will be a continuous demonstration of the complete process of making castings. The making of the mold by the imprint of the pattern in the sand of the molding flask will be followed by the melting and pouring of the metal into the mold, the piece being removed from the sand as soon as it is cool. Elaborate pieces requiring the use of cores will be made, and modern methods of machine molding to save time and labor will be demonstrated. Downstairs in the Pattern Making Laboratory the modern methods for the rapid cutting of patterns are used, each student being provided with an individually driven

(*Continued on page 92*)

The Pictorial Section

Some of the newer trends in design of locomotives, as shown in pictures in this issue

THE past year will go down in railroad annals as one of great importance for two reasons. The first of these is the celebration of the 100th anniversary of the opening of the first railroad, the Stockton & Darlington Railway in England on September 27. This event is of great significance when we realize what a short time it has been for railroading to reach its present state of development. The second of these reasons is the remarkable advancement in locomotive design during the past year, resulting in higher efficiencies than have ever heretofore been attained. Among these improvements may be mentioned the use of feedwater heaters and superheaters which secure higher thermal efficiencies than would be otherwise attained. Mallet locomotives making use of compounding and three cylinder locomotives have also been developed during the past year.

Electric locomotives have now supplemented the steam locomotive for terminal work in congested areas and for regular service on the mountain lines of certain roads, notably the Virginian and the Chicago, Milwaukee & St. Paul. Where traffic is extremely light on branch lines or where there are other factors making electrification impractical, Diesel electric, oil electric, and gasoline electric locomotives have been installed with excellent results.

On the following pages some of these improvements are shown in pictures. Figure 1 shows the smoke box of a Lima locomotive. The boiler is of the five-tube type and the flames are drawn through the tubes by an artificial draft produced by the exhaust steam. This picture shows the exhaust pipe in the center foreground with the inlet pipes at the side of the casing.

Figure 2 shows the cab of a Lima locomotive, which is considerably neater in the arrangement of controls than previous locomotives and provides the maximum of comfort for the engineer. Figure 5 shows a front view of the Texas locomotive, built by the Lima Locomotive Works, and clearly shows the feedwater heater mounted at the top of the boiler. The exhaust steam and flue gases warm the incoming water, which avoids a drop of pressure in the boiler. This engine is unique in having the pumps for the air-brake system mounted in front of the boiler behind shields, giving a very neat exterior. Figure 7 shows one of the large freight engines of today equipped with feedwater heater and the other accessories.

Figure 6 shows the booster truck used on the Lima type of locomotive. The booster consists of a small supplementary engine mounted on the trailing truck, which greatly increases the draw bar pull. The Lima engine develops a tractive power of 69,400 lbs. without using the booster, while it develops 82,600 lbs. with booster. These figures show the value of this latest development in mountain service where high tractive powers are needed.

Figure 17 shows the new Lima type locomotive, which is one of the most powerful and efficient freight locomotives in operation today. Note the power reverse mechanism on the side and the general neat appearance compared to older types with a multiplicity of pipes on the side of the boiler. Figure 9 shows a large Mallet locomotive, built by the American Locomotive Works. This type takes full advantage of high pressures and has taken its place in American railroading practice. Figure 16 is another Mallet locomotive, and is a high-pressure articulated type.

Figure 12 shows the "Horatio Allen." It is a high-pressure experimental locomotive built for the Delaware & Hudson. It operates at about twice normal boiler pressure, and a great performance record is claimed for it.

Figure 8 shows one of the Pennsylvania electric locomotives used to haul their trains through the Hudson tubes from Manhattan transfer to New York City. These engines are built by the Westinghouse Company, and embody a great many interesting features. It uses single-phase A.C. current at 11,000 volts taken from an overhead trolley. By very clever designing, these engines are equally well fitted to haul either passenger or freight service. Note the individual motors driving the counterbalanced wheels through side rods. Figure 11 shows another electric locomotive, which is familiar to most of our readers, the famous engine of the Olympian, the "crack" train of the Chicago, Milwaukee & St. Paul R. R. This engine operates on a voltage of 3000 volts D.C. and has a great many interesting features. Regenerative braking is employed which consists of allowing the energy of the decelerating train turn the motors as generators feeding the current produced back to the lines. The motors are mounted directly on the axles, eliminating all gearing and greatly increasing efficiency. Figure 13 shows one of the rotary electric snow-plows used on this same road to keep traffic open during the winter on the stretches through the Rockies.

Figure 15 shows a 600-volt D.C. locomotive used to haul the limited trains of the New York Central from Harmon down to New York City. This engine is equipped with eight motors and has a very high tractive power. The cylindrical cylinders mounted vertically at both ends are sand boxes used in sanding the rails.

Great progress has been made during the past year in oil, Diesel, and gas electric work. These engines have now been developed to a very high degree, and some have distinguished themselves already. Figure 14 shows a Diesel electric articulated railcar which has just crossed the continent and proved the reliability of Diesel electric equipment. Note that one truck serves as a support for both the front end of the rear car and the rear end of the locomotive proper.

Figure 10 shows a gasoline electric car propelled by two Winton gasoline engines and General Electric electrical equipment. The radiator for cooling is placed on the roof, as in airplane practice.

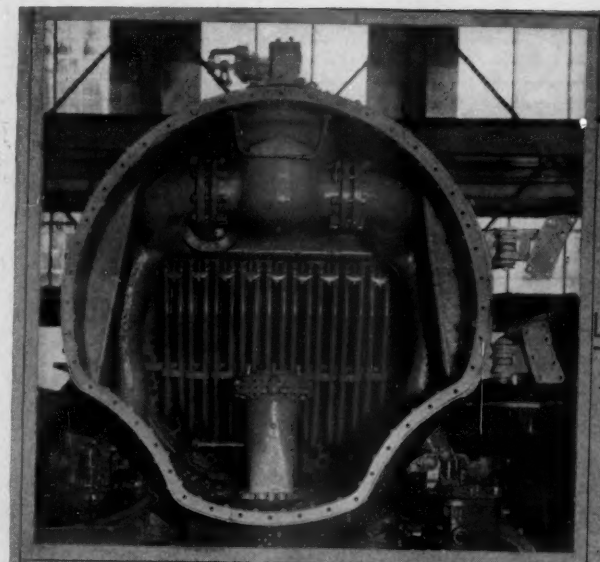
Figure 18 shows an oil electric locomotive built by the General Electric Company for the Long Island Railway. This locomotive performed quite satisfactorily on its recent test run.

Figure 3 shows a New York Central locomotive equipped with electromagnetic automatic train control. The operating unit may be seen on the tender directly above the rails. By the use of this apparatus, it is impossible for an engineer to disobey signals, as the throttle is automatically closed and the air brakes applied when a danger block is met.

Figure 4 shows the car retarder used in the freight yards of the New York Central to control the freight cars when they are uncoupled and allowed to roll along in the making up of a freight train. The steel bars shown in the figure are pressed against the flanges by compressed air.

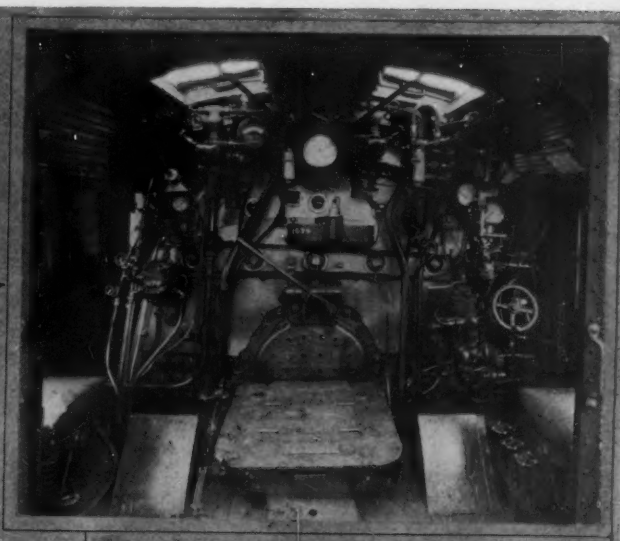
These pictures show that the railroads of the country are losing their conservatism, and new features, adding to the pleasure and economy of travel, are being added as rapidly as possible. If as great progress is made in the next one hundred years as has been made in those just closed, railroading will undoubtedly be the highest type of engineering.

A. K. STRICKER, '29.



← FIG. 1 SMOKE BOX

FIG. 2 → LOCOMOTIVE CAB



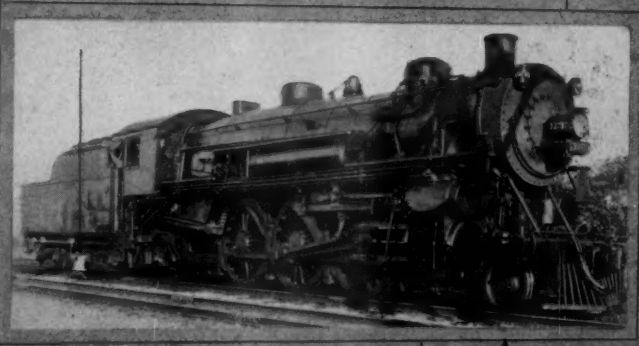
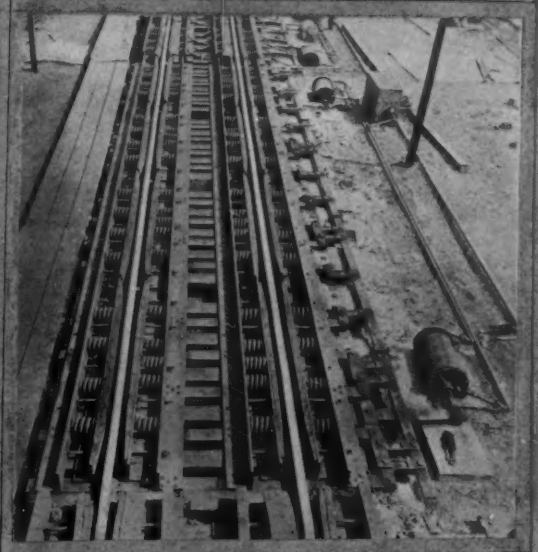


FIG. 4 → CAR RETARDER



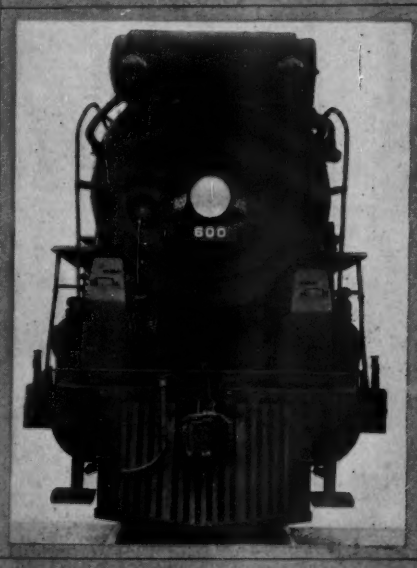
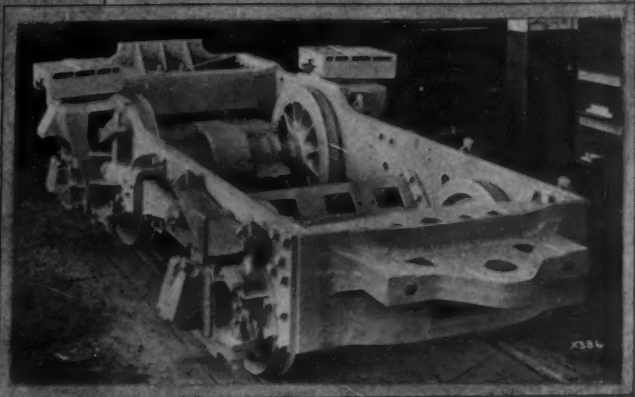


FIG. 3 LOCOMOTIVE WITH AUTOMATIC CONTROL

←FIG. 5 FEED WATER HEATER

FIG. 8 BOOSTER TRUCK →



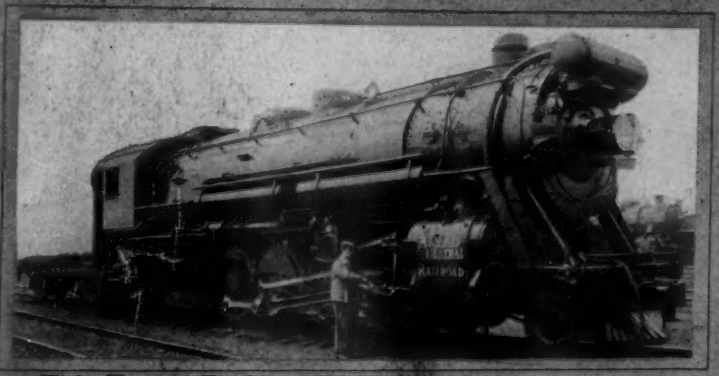


FIG. 7 LARGE FREIGHT

FIG. 8 PENN. ELECTRIC

FIG. 9 MALLET LOCOMOTIVE

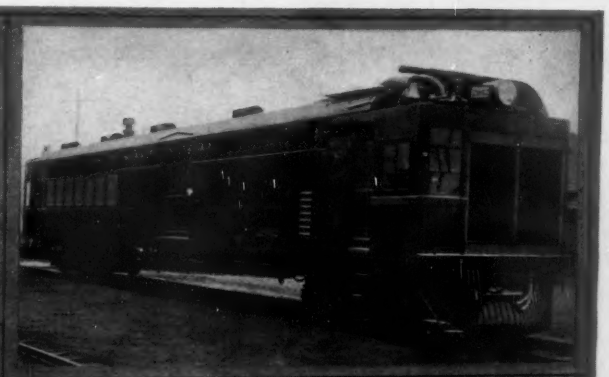


FIG. 10 GAS-ELECTRIC CAR

FIG. 11 OLYMPIAN

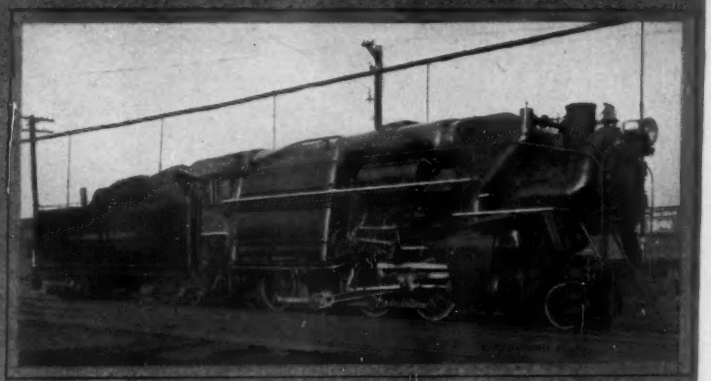


FIG. 12 HORATIO ALLEN

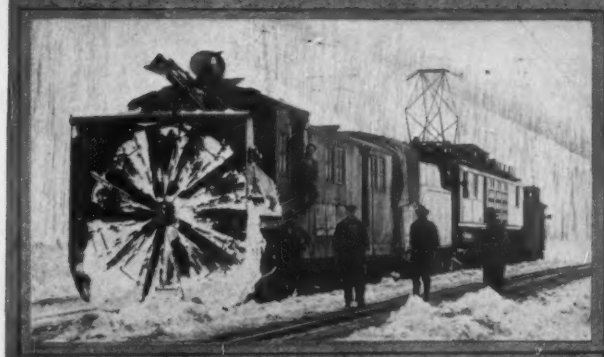


FIG. 13 ROTARY PLOW

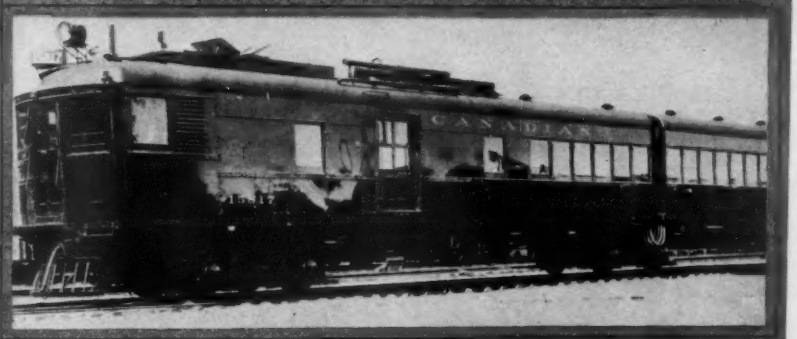


FIG. 14 DIESEL ELECTRIC CAR

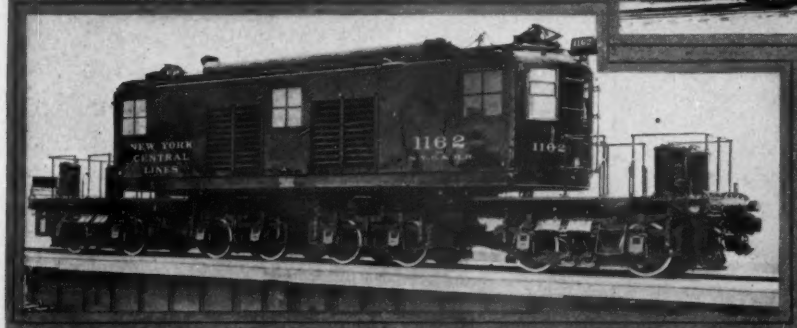


FIG. 15 600V-DC ELECTRIC LOCOMOTIVE

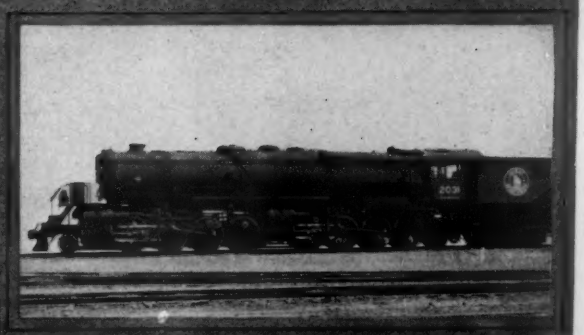


FIG. 16 ARTICULATED MALLET

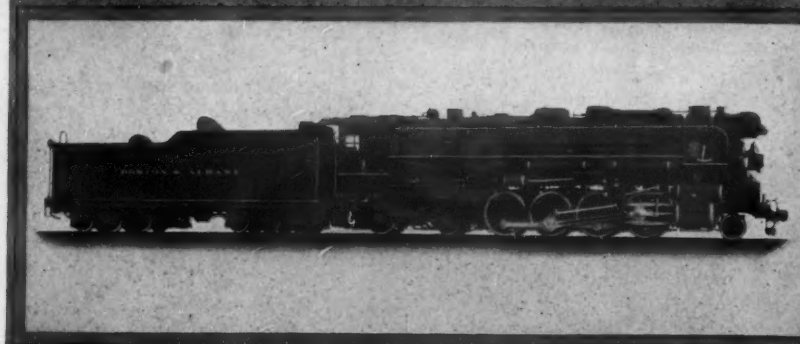


FIG. 17 FREIGHT LOCOMOTIVE ON B & A

FIG 18 OIL-ELECTRIC

Editorials

COURSES VERSUS CLASSES

It is with considerable hesitancy that we criticize any activity that helps or might help the anemic "spirit" at Technology. It is even more difficult when that activity is of changing value. There can be no doubt that to the alumni the class organizations are very important. Much good has been done by the graduated and graduating classes as units. The organization of the senior class is very helpful; the senior class officers are able and have important functions. The junior class, on the other hand, has at present one reason for organization — Junior Week. Even here, however, almost all official activities are carried on largely by the Junior Prom Committee. How many juniors can name their class president, and of those who can, how many can name any of their other officers? The same question might well be asked with even greater effect of members of the two lower classes.

We do not feel, however, that because of the doubtful prestige and questionable usefulness of the class officers and class organizations, that they should be done away with. Much has been said of the fostering of these class organizations, and predictions are often made that with the growth of the Institute "campus" they will gain strength; but after all, under the present conditions isn't the reason that the class organizations are not important due simply to the fact that there is no real necessity for them? What purpose would class meetings serve at Technology if they were held?

The avowed purpose of the so-called liberal arts school is to make men. Technology has a bigger job. She must not only produce men, but men that are gears — gears designed and finished to fit in the machine of human progress. It is a debatable question whether the system that applies to a liberal arts college is the best to transfer bodily to an institution of the type of Technology.

We are not advocating the abolishment of the present system, but we feel that a good deal of thought could be directed to the reorganization of the classes along course lines. In other words, why would it not be possible to have course organizations and course officers, including at least the three upper classes. The necessary administrative machinery could be much the same as that used in the fraternities and other college organizations where the personnel of the group is regularly and automatically changing from year to year. The course president would necessarily be a senior, but the other officers could be picked from all the classes. Over the course organizations could then be built the superstructure of the classes. It is conceivable that a form of student government could be set up in which each course had a representative on the student committees of each of the four classes, the class officers of which would be nominated from the course society or from the student body.

The advantages from such a system would be many. The students would have direct contact with the men that were ahead of them in their own fields. They would be able to learn sooner whether the course was suited to their real ambitions and aptitudes. The course organization or society could and would be expected to absorb the professional society that served its field. By combining the course organization with the professional society, it might be possible to arouse the kind of spirit that would appeal to the type of man who is, or expects to be, a professional man. A great many of the courses are very theoretical — and rightly so — and the men in the lower classes find it very difficult to connect them with anything that even remotely resembles the practical. It is much more important to have a student interested in his work than to have him expert in working problems. The course societies would help to generate and retain this interest.

If a step of this kind is too drastic to be undertaken at once, we feel that a great deal could be gained if the course societies could be organized to supplement the classes. Some work along this line has already been started in one or two of the courses, but it is something that should be fostered by all fifteen. It would help a good deal in humanizing the contacts at the Institute and would develop a rivalry and an *esprit de corps* that is now only feebly existing.

AN OPPORTUNITY

Some months ago an editorial appeared in *Power* dealing with the publication of articles and letters by technical men. In it were stressed the possibilities which such a practice offered. Since the original article, several letters have appeared in the same journal relating to successful experiences or drawing attention to some of the difficulties to be met with in seeking to follow this course.

They are valuable reading. The matter is one which is of great importance to engineering students. There are technical journals today specializing in all the well-known and many of the less prominent branches of engineering. Through their columns a man has an opportunity of placing his ideas before those most vitally concerned with the matters he deals with. Technical journalism is without a purpose if it be not to encourage progress through the fullest possible exchange of ideas. The existence of each publication depends upon its capacity to interest those whose main concern is with the field it covers. Editors must maintain this interest, and a continual search for suitable matter is the result. New ideas of great value, and experience that is equally useful, need not necessarily come from those whose reputations are already made. If a man's ability is in any way above the ordinary, it is certain that a few years' work in a particular field will find him with ideas of real value. It may well be that many of these are of such a nature that permission to publish them could be obtained readily. There are difficulties, of course, to be overcome before an article appears in print. If men take every opportunity to gain some ease in writing, they will be helping to remove one of the greatest of these, and the others are no greater than those attendant upon any enterprise.

Action of this kind can scarcely have other than good effects. A communication that is worth printing is very likely to promote discussion. If the writer's views are sound, he will be given credit for them by thinking readers. If unsound, they will not go long unchallenged, and the author, perhaps, will be saved from a costly fallacy. In either case, something has been added to knowledge.

If a man have something worth while to say, and can say it with reasonable clearness, a little effort expended in getting his views into print may well bring him recognition in a few years which otherwise might be given only after the work of half a lifetime.

ENGINEERING EDUCATION

There are a great many investigations of different kinds now operating in the field of engineering education which are bringing to light a variety of interesting things. The most attractive, to us, has been the returns from a set of questionnaires sent by Dean Turneaure, of the College of Engineering, University of Wisconsin, to each alumnus, to obtain his opinion of the engineering curriculum.

The point stressed in most of the answers was that the scope of the engineering courses had been too limited. Suggestions were made for broadening the courses, not by increasing the number or thoroughness of the scientific and engineering sub-

(*Continued on page 96*)

The Engineering Field

Excerpts from the leading professional and trade journals

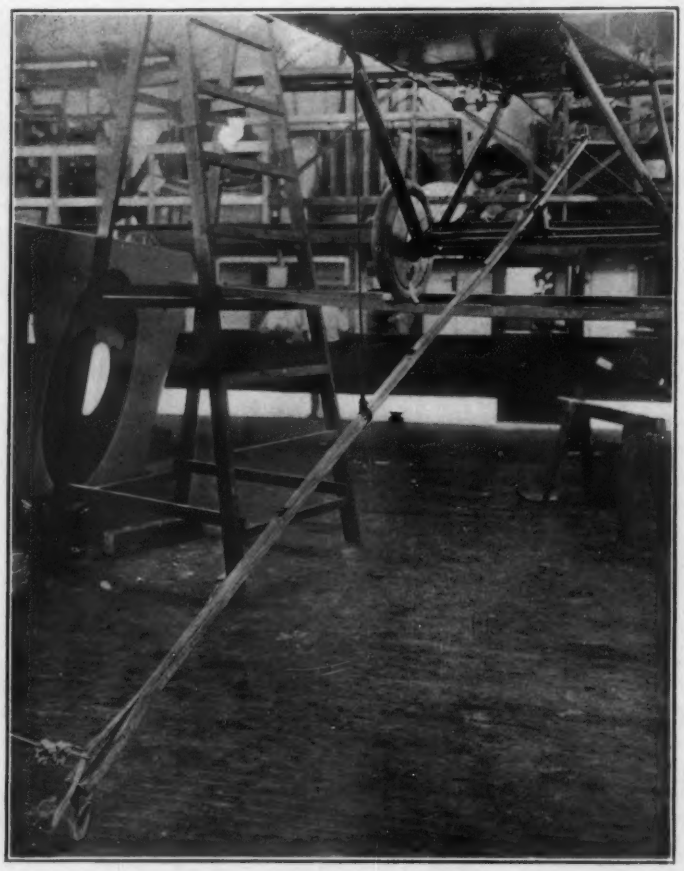
All-Welded Swimming-Pool. An electrically-welded steel tank for a swimming-pool 60 x 30 ft. has been installed on the sixth floor of the Standard Club Building in Chicago. The tank consists of ⅜ in. bottom and side plates, the bottom plates resting on longitudinal I-beams, inclined to accommodate the varying depth of tank, while the sides and ends have stiffeners of 7 in. channels.

Transverse trusses and girders support the bottom I-beams which rest on wedge-shaped cast-iron blocks cored for bolts which pass through the flanges of the beams and girders. Upon these I-beams are laid the bottom plates which are 6 ft. wide. At the longitudinal seams the edges of the adjacent plates rest on an I-beam with their edges ¼ in. apart. The plates are then welded continuously to this beam and the longitudinal ¼ in. channel is filled with metal by the same process, thus forming a flush bottom. The floor plates are connected to the intermediate I-beams by tack welds. The bottom plate extends far enough beyond the sides to serve as a seat for the 7 in. stiffeners, which are welded to the side plates. A longitudinal channel supports the edge of the bottom plate.

No special provision is made for expansion and contraction since the tank is small and is in a building where there will be only slight variations in temperature. A layer of concrete reinforced with wire-mesh is laid upon the steel plating and is covered with the glazed tile lining. This lining is shaped to form the scum trough. The ceiling under the tank is a concrete slab in which the bottom flanges of the trusses and girders are embedded, giving a headroom of 11 ft. 3 in. and 13 ft. above the finished surface of the floor below.

Where pipes enter the tank, they have flanges welded to both sides of the plating, while a large drain box in the bottom is fitted to a flange welded to the plate around the opening. Both shop and field connections were welded throughout, no rivets being used in any part of the tank. The total weight of plates, stiffener channels, and top and corner angles was about 25 tons. —*Engineering News-Record.*

A New Brick for building purposes is being produced from furnace ashes and clinkers which have been roughly ground and then mixed with definite proportions of lime and water. The bricks are molded from this mixture and piled on cars which are run into a steam chamber. After the chamber has been sealed, steam is admitted at 120 pounds pressure for about six hours. Following this treatment the bricks are ready for use as soon as they have cooled.—*The Chemical Age.*



AIRPLANE ARRESTER POLE CARRYING HOOK, LOWERED TO OPERATING POSITION

Airplane Arresting Device. After the development of the catapult for launching airplanes from restricted areas, there remained the problem of landing them within small spaces. In 1921, tests were carried on by Mr. Hazen C. Pratt, before the Navy, of an apparatus which stops an airplane far more effectively than an express train or automobile is stopped by its brakes. The part of the gear carried on the airplane consists of a long, light pole carried underneath the plane, pivoted at one end and carrying a detachable hook on the other, with some means for raising and lowering. The hook is attached to a cable which is fastened to the plane near the tail in such a manner that the decelerating force acts through the center of gravity of the plane. The apparatus on the ground or landing platform consists of a cable or chain, or a series of them, stretched parallel to the landing surface and at right angles to the path of flight, at six and twelve inches above the landing surface. The ends of the horizontal cable or chain are connected to other cables wound on reels which are equipped with brakes.

In operation, the pilot lowers the pole before he approaches the landing surface so that the hook is below the wheels of his plane. He flies over the stretched cable at such an elevation that the wheels of the plane are within three to four feet of the landing surface. The chain or cable is struck by the pole and guided into the hook, which becomes detached and allows the pole to be automatically returned to the inoperative position. The connection now established between the airplane and brake allows the application of a negative acceleration equal to three or four times the acceleration of gravity, which will bring the plane to rest within a very short distance. In the tests, the plane was brought from 50 m.p.h. to a stop within 132 ft. following engagement, or 112 ft. following application of the brakes, while the landing was smooth.

The flying speed permissible at engagement is moderately high and allows the airplane to continue under full control if engagement is not made. The leeway in piloting is fairly large — two to three feet vertically and ten to fifteen feet laterally. It is not necessary to throttle the engine, as the retarding forces are so large as to make the tractive effort of the propeller of little consequence.

As used for the past two years, without a single accident, on the aircraft carrier U. S. S. Langley, the pole carries the hook at all times, is short, hinged to the plane at a point about midway between the wheels and the tail surfaces, and the retarding force is transmitted through it. The Bureau of Aeronautics has stated its intention of equipping the aircraft carriers now under construction, the U. S. S. Lexington and the U. S. S. Saratoga, with devices of a similar nature. —*Aviation.*

The Mechanical Locomotive Stoker. After many years of experimentation and development work the firing of locomotives by mechanical means is now a successful accomplishment, and practically all new locomotives built today that come within what is considered mechanical stoker requirements are equipped with a machine for stoking the locomotive, known as the Locomotive Stoker.

The prime purpose of the locomotive stoker is not what at first might be assumed—to promote fuel economy, but rather to increase the capacity of the locomotive or to make larger locomotives possible. This results in increased earnings for the railroad and permits the building of the immense locomotives constructed today, which are admittedly beyond the capacity of a man to fire by hand—just as in the large steam or electric power plants no one would attempt to fire the boilers by the use of a single fireman, so in the larger locomotives they use the locomotive mechanical stoker, which is designed along widely different lines from the power plant mechanical stoker.

While in stationary power plants the coal is burned evenly and rather slowly, with a uniform load on the boiler, very different conditions prevail on locomotives. A locomotive stoker must be so designed that it can handle different types of fuel and be controlled by the fireman, to take care of the varying loads and speeds of the train. The locomotive stoker consists of the following parts: driving engine, conveying system, elevating system, and distributing system. The driving engine consists of a steam cylinder and piston which drives through a rack the vertical elevators and the horizontal conveying screws. The conveying system consists of a worm which breaks the lumps to the proper size and brings them from the tender to the engine. The conveyor is controlled by changing the speed of the driving engine. The coal is delivered from the conveying screws to the two vertical elevators, which consist of similar screws driven by the same engine. The coal is then distributed to the grates by jets of steam which direct the coal to the different parts of the grate, which thus receives even distribution. The distribution is under complete control, as the speed of the driving engine and the steam pressure on the jets are under the fireman's observation and control. The fireman can also reverse the stoker so as to remove any foreign matter which may fall into the conveyor.

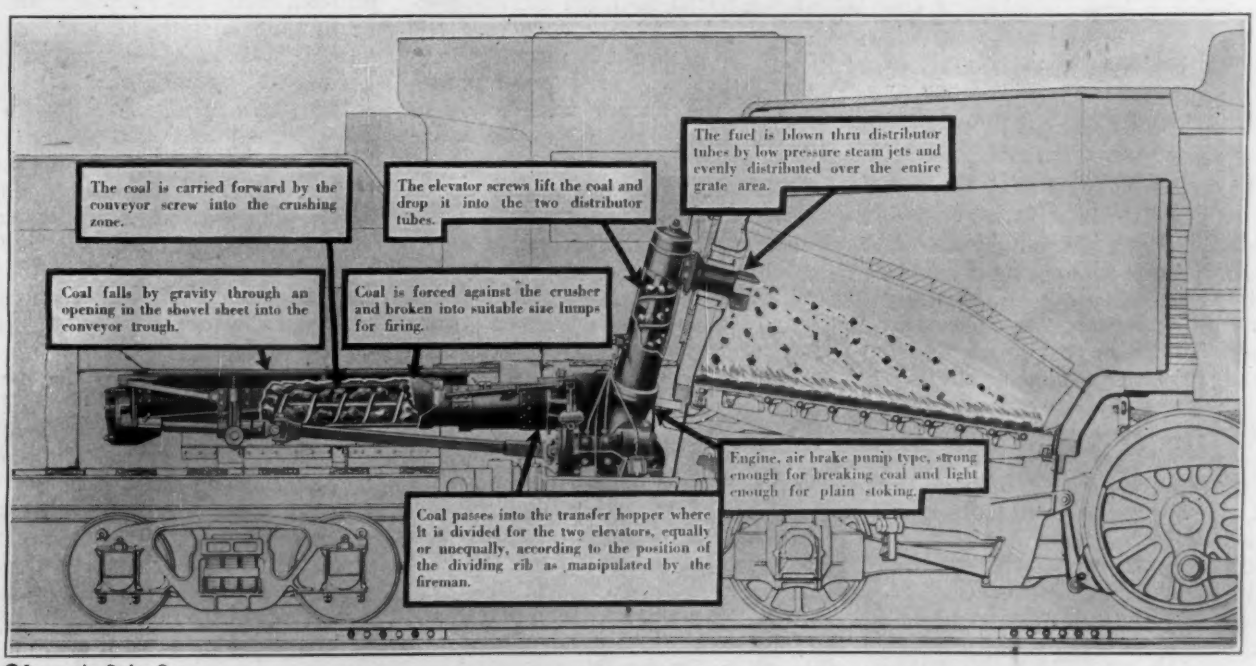
The exhaust steam from the driving engine is used to dampen the coal, thus giving higher efficiency.

The stoker uses only one per cent of the boiler capacity and enables the enormous grate areas of the present large locomotive boilers to be fired.

Temperature Control has been suggested by two German chemists as a method for eliminating the loss of gas in airships. The present method of valving the gas as the temperature and load change is a very wasteful and expensive one, especially when helium gas is used. Their method is to heat the gas electrically at the beginning of the voyage so that its buoyancy is increased and the carrying capacity of the ship is thereby improved. As the fuel is burned up and the load becomes lighter, the temperature of the gas is allowed to decrease and equilibrium is thus maintained. The temperature of the gas is regulated by means of thermostatic control. This control has worked very satisfactorily in all laboratory tests, and no reason is seen why it should not work on actual airships. —*The Scientific American.*

Flexible Glass is to be produced on a commercial scale in England by Dr. Pollak and Dr. Ripper, the inventors. This glass is a condensation product of carbamide and formaldehyde, and can be produced either in the liquid form, a thick syrupy substance, or as a solid. Although not quite as hard as plate glass, it has the same appearance and a greater tensile strength while only one half as dense. This glass is so flexible that a rod of it can be bent to a half circle without breaking. When it does break the fracture is blunt and without splintering. It can easily be turned on a lathe, drilled, filed, or polished. What is perhaps of greater importance is that this glass transmits ultra-violet rays, which adapts it for use in hospitals and greenhouses. Other uses for it are in the manufacturing of enamels, varnishes, and as a basis for artificial silk and lapidary work.

City's Water from Glacier. The acting city manager of Boulder, Colo., has been instructed by the city council to purchase from the United States Government the land occupied by the Arapahoe glacier, which is about fifteen miles from the city, in order that the glacier may be used to supplement the city's water supply.—*Engineering News-Record.*


The coal is carried forward by the conveyor screw into the crushing zone.
The elevator screws lift the coal and drop it into the two distributor tubes.
The fuel is blown thru distributor tubes by low pressure steam jets and evenly distributed over the entire grate area.
Coal falls by gravity through an opening in the shovel sheet into the conveyor trough.
Coal is forced against the crusher and broken into suitable size lumps for firing.
Engine, air brake pump type, strong enough for breaking coal and light enough for plain stoking.
Coal passes into the transfer hopper where it is divided for the two elevators, equally or unequally, according to the position of the dividing rib as manipulated by the fireman.

©*Locomotive Stoker Co.*

ILLUSTRATIVE DESCRIPTION OF OPERATIVE PARTS OF THE DUPLEX STOKER

Here and There

Interesting notes from the Editor's desk

EFFECTIVE REGULATION

The Old East has solved a problem which was probably made acute by American quantity production methods. The solution reached, as recounted by *Industrial Gas*, might be helpful to our city of Cambridge in its attempt to keep automobiles from the safety zones on Massachusetts Avenue opposite Tech.

Dr. Emin Bey, who is nothing if not an energetic prefect of Constantinople, has hit upon a very effective device for imposing upon motor drivers that carefulness which has been so conspicuously absent in the past.

He has issued to the police, planks of wood studded with nails, and has given public notice that the police have been authorized to throw these planks about one yard in front of any approaching motor car as they may see fit. In case the car does not stop in time to avoid having its tires either punctured or cut by the nails, this will be regarded as proof that the brakes are defective, and the chauffeur will be punished accordingly.

So far the police appear to have made comparatively little use of these new powers, but the mere threat has had a singularly good effect. Whereas quite recently it was a risky thing to cross even the narrow streets that obtain here, motor cars are now going at such a demure pace that one newspaper has published a cartoon wherein a man, upon being asked by a driver whether he wants a car, replies: "No, thank you. I will take a cab, as I am in a hurry." The threat has been the more effective in that quite a large number of the motor cars are owned by the drivers themselves, so they would be out of pocket each time they spiked one or more of their tires upon a plank.

WHAT WE KNOW ABOUT THE AURORA

In March, 1920, the inhabitants of the United States witnessed one of the most beautiful displays of northern lights of which we have any record in this country. This event probably led thousands of people to consult old textbooks in order to find out what causes these celestial fireworks.

A great fund of information has recently been acquired concerning the aurora, chiefly by a group of Norwegian physicists.

It has been known for years that there is some sort of connection between auroras and solar activity. The nature of this connection has now become quite clear. The sun, due probably to intense excitement of the atoms due to the great heat, sends out ether waves of widely varying wavelengths, and electrified particles, some of which enter the earth's atmosphere. Whenever, due to local changes on the sun, this bombardment becomes especially intense, the highly rarefied gases of the atmosphere are set aglow by the passage of the electrical discharge, and the visible aurora is thus produced.

The display tends to be concentrated in two belts surrounding the Arctic and Antarctic regions.

How does it happen that the electrified particles from the sun are thus segregated in high northern and southern latitudes, instead of being spread impartially over the globe? And why is the aurora seen at all at night; i.e., on the side of the earth turned away from the sun?

The reason is that the electrical streams from the sun are strongly deflected from their course by the earth's magnetism. This was first proved by the late Prof. K. Birkeland, who produced in his laboratory a miniature aurora by suspending in a glass vessel, exhausted of air, a magnetized metal sphere representing the earth, and exposing it to a discharge of cathode rays. The sphere was coated with a phosphorescent substance, which glowed under the discharge. The glow was found to be confined to two zones surrounding the poles of the magnet, and corresponding roughly with the auroral belts of the earth.

Since this experiment has been performed, Prof. Carl Stormer, of the University of Christiania, has calculated the paths that the electric particles must follow in approaching the earth, by an exceedingly intricate work of mathematics. Fairly good photographs of the aurora were made as early as 1892. Recently, by using stations connected by telephone, and carefully observing the angles at respective stations, the height of any feature of the discharge can be easily calculated. The average height has been found to be about 200 miles, although some streamers extend down as low as 54 miles, and others have been observed as high as 450 miles.—*Tycos.*

INGENUITY

Nature and the human mind matched wits. This time nature lost when a bridge contractor built a 100-ft. steel bridge span on the river bank and then snaked it into place.

Twice the piling had been placed and the falsework constructed, all ready to start on the steelwork—the usual procedure. Twice the river swelled to flood size and washed everything out. All right, the workmen were told to go ahead and build the bridge span right there on solid ground. They did. Then the falsework was put in again, timbers were greased, and just one hour was spent in pulling the span along into place by a large tractor on the other bank, and bolting it down to the abutments. The river didn't have a chance. —*Scientific American.*

ONE DIRTY CITY GETS 794 TONS OF SOOT PER SQUARE MILE

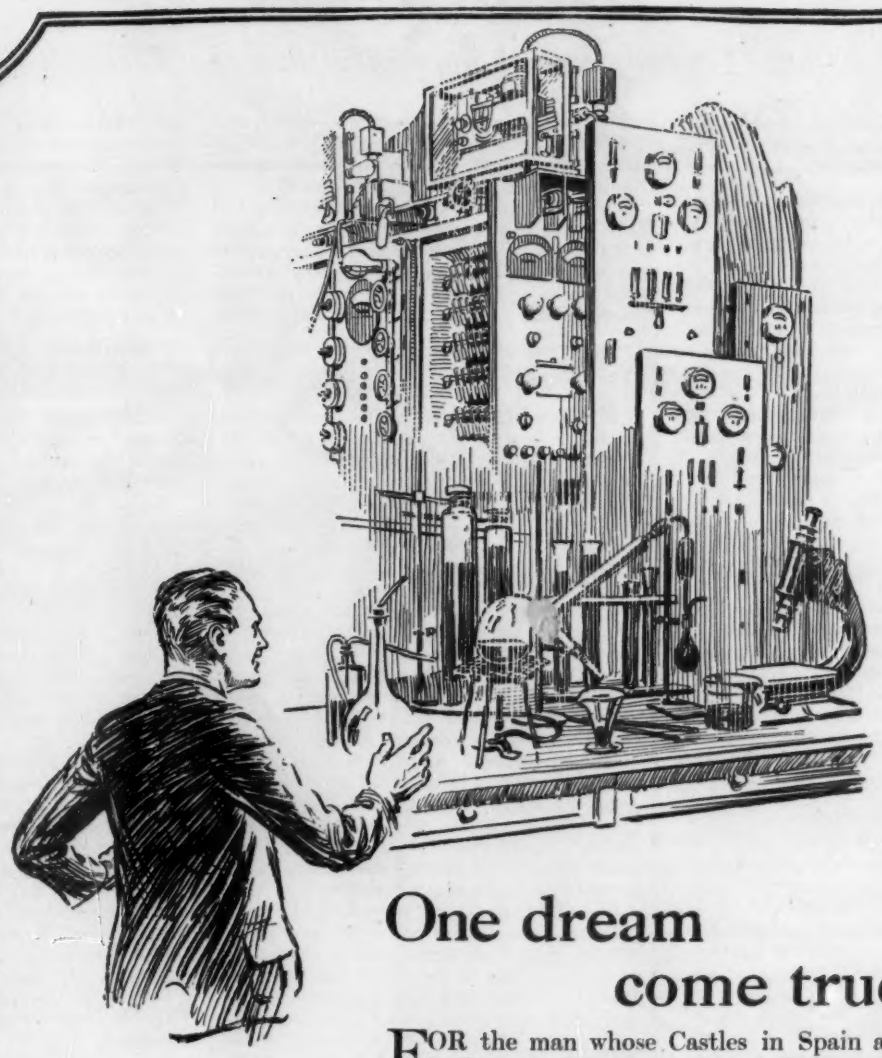
In a thorough scientific investigation and analysis of the pollution of city air by smoke, it was found that the nitrogen content of the smoke was of no use in fertilizing the soil. The soot from industrial chimneys contained too little nitrogen, and the soot from domestic chimneys, which is the chief curse of our great cities, contained so much tarry matter as to be useless as a fertilizer. The tarry matter clogs the pores of plants and ultimately stunts or kills all vegetation. The figures which were accumulated on soot precipitation showed that of ten large cities, the cleanest community had a total deposit of 101 tons per square mile, while the dirtiest deposited from the air 794 tons of impurities per square mile.

THE RAILROAD MAN'S PRAYER

There is enough railroad material in this issue to make this story very timely. It is to illustrate the effect on a person of environment. It seems that a railroad man "got religion," and when he announced that he had been converted, was asked to lead in prayer. This is the way he did it:

"Oh, Lord, now that I have flagged Thee, lift my feet off the rough road of life and plant them safely on the deck of the train of salvation. Let me use the safety lamp known as prudence; make all couplings in the train with the strong link of Thy love. And, Heavenly Father, keep all switches closed that lead off to sidings, especially those with a blind end.

"Oh, Lord, if it be Thy pleasure, have every semaphore blocked along the line; show the white line of hope that I may make the run of life without stopping. And, Lord, give us the ten commandments as a schedule time, and when my train shall have pulled into the great dark station of Death, may Thou, the Superintendent of the Universe, say with a smile: 'Well done, thou good and faithful servant; come up and sign the pay-roll and receive your check for eternal happiness.' "



One dream come true

FOR the man whose Castles in Spain are built in the laboratory, here is the promise of a dream come true.

In communication research, men have seen a thousand great visions in little test tubes, hundreds of new thoughts reflected in the mirrors of galvanometers.

A life-time of this work is waiting for the man who loves it, and under conditions that he has always longed for. A wealth of apparatus and materials, an abundance of knotty problems, a group of associates who are helping in the great work—these are a natural part of this far-reaching industry.

The requirements of communication call for deeper, ever deeper inquiry, and not only along electrical lines but in chemistry and mechanics as well—all science contributing the stuff of which the researcher's dream is woven.

Published for the Communication Industry by

Western Electric Company

Makers of the Nation's Telephones

Number 57 of a series

Recent Books

This department conducted in co-operation with the Technology Library

The Invention of Business Problems. By J. Eigelberner. New York: A. W. Shaw Co., 1926. 330 pp.

The author of this book, an Industrial Engineer, has expanded into book form instructions which he has used in breaking in new research men. He says that investigation is largely an attitude of mind and that this attitude may be developed with proper training. He has written the book to fill a need for an orderly procedure for training research men, and as such it fulfills its purpose well.

The book takes the subject up in a clear and logical manner, going through all the necessary steps in a business or an engineering investigation. The first chapter is introductory. It outlines the field of engineering and commercial research and shows the necessity for a scientific analysis of problems. The author then starts in on his subject by outlining the necessary steps in carrying on an investigation. These are the steps usually given as essential in preparing a report. The rest of the book is an explanation of the methods and information necessary for each step.

The first thing that is discussed is the qualifications of the investigator. These qualifications are in such broad terms that they might as well be called the qualifications for any other kind of professional work, and anyone with all of the personal qualifications listed would not be a failure in any line of work. The author includes here a self-quiz and self-rating chart which would prove of value if used honestly. He then gives a percentage valuation of the personal qualifications necessary for the investigator. It is difficult to measure men quantitatively, but always interesting, and may be made a means of self-improvement. In the discussion of the preliminary analysis, there is a discussion as to the most practical point to begin on investigation. This is a point often neglected but always important. Continuing the discussion of the first steps, he warns against and classifies various kinds of prejudices and gives helpful suggestions to overcome them. The next few chapters deal with the methods of collecting facts, taking up, in turn, personal observation and experiment, bibliographical research, interviews and questionnaires. These chapters should prove most helpful to an inexperienced man. Before the discussion of the actual gathering of facts, he discusses the mechanics of research work and considerations necessary before the collecting of facts is really started. Throughout the book the author gives the elementary rules in a concise form for handling the points under consideration and then elaborates on them. In the chapters on gathering facts, he gives rules of developing concentration on observations. In the chapter on bibliographical research, there is a valuable list of sources of information of various kinds and various indexes of current publications. These should be familiar to the engineer. Practical suggestions are given for conducting an interview, and then for the used and abused questionnaire.

The next few chapters deal with using data after they are collected. They start with a discussion of the kinds of thought and the functions of thinking, followed by the necessary tools of thought, definition, and classification. He next considers six questions which must be answered in order that the facts may be tested and interpreted so that they will be ready for tabulation and presentation. The tabulation and presentation of facts are subjects which can always be profitably elaborated upon, and the author makes good use of the short space he has for this. Especially valuable is a knowledge of the technique of tabulation, which is often overlooked in the training given in schools, and a discussion of the meaning and value of various statistical averages, a necessary understanding to use them intelligently.

The rest of the book deals with forming and establishing conclusions and the preparation of the report. First is a chapter on suggestion and influence. This is where the true investigator shows up; many of the other methods necessary can be cultivated, but as yet there is no way to make a person inventive or fertile in his suggestions, he must have some constructive imagination. The following two chapters take up a discussion of types of reasoning and their use in developing and establishing a conclusion. The conclusion is developed by inductive reasoning and established by deductive reasoning.

The last chapter treats with the preparation of the report — this is conventional. The chapter is ended by a critical analysis of a typical report.

Too important to be neglected is a list of selected references. These are grouped by chapters, and the list forms a bibliography which should prove of value to the going engineer. The list contains leading and accepted books on research, statistics, management, marketing, organization, personal efficiency, accounting, psychology, logic, and report writing.

This book should be a valuable addition to the library of the young engineer, especially the industrial engineer. Although the title refers to business problems, the whole book infers engineering reports. The author himself says that it is written from the standpoint of the engineer. The book is carefully marked out, and is clearly the result of time and serious effort. It is full of practical suggestions and examples to illustrate the rules laid down. Many of the ideas are explained from the standpoint of practical psychology and logic, thus making them clear and impressing them on the mind. The graduate of a good engineering school has heard most of the principles at one time or another, but here they are collected in concise and readable form where he may review them from time to time.

A LIBRARY EXHIBIT

A selection of early books and pamphlets on electricity has been placed on exhibition in the central library. This includes the oldest book in the possession of the Institute, "Margarita philosophica . . . ," published in 1508, and bound with covers of solid wood. There is also on display the first edition of "De Magnete," by William Gilbert, printed in Latin in 1600, and beside it a modern translation in facsimile, which reproduces the original illustrations and the author's marginal notations. Gilbert has been called "the first electrician," and published this work only after eighteen years of investigation and experiment. He used a large asterisk to mark what he considered great discoveries, and small asterisks to emphasize the minor, there being 21 of the former and 178 of the latter scattered through the text. Original papers by Ampère, Ohm, Oersted, Christie, and other pioneers in the electrical field are also shown, a special feature being several "Presentation pamphlets," bearing inscriptions in the handwriting of the various authors.

The exhibit was arranged by Mrs. Maynard, the Vail Librarian, in connection with a talk recently given to the sophomores in Course VI on "The Library as an Aid in Electrical Research." In this talk Mrs. Maynard told the story of the acquisition of the Vail Collection by the Institute in 1912 through the gift of the American Telephone and Telegraph Company. The collection originally comprised 15,000 books and some 18,000 pamphlets, to which have been added all important subsequent publications in electrical engineering. The library is therefore unusually well equipped for intensive research from the historical viewpoint as well as along the lines of progressive development. Naturally, it is the more recent books and periodicals that form the working collection of practical value to the students in Course VI.

Telephone Communication Systems. By Royce Gerald Kloeffler, New York: The Macmillan Co., 1925. 279 pp.

This comprehensive and informing book comes out appropriately at a time when the fiftieth anniversary of telephone communication is being widely celebrated. Recent progress in telephone engineering has followed two major lines of development, that of increasing the distance of verbal communication and making wider application of the automatic system to meet the traffic conditions in large exchanges. Intercontinental communication is now a regular feature of long-distance telephony by a combination of wire and wireless, and the Bell System has adopted the policy of gradually changing over its entire service from manual plants to full automatic switching.

Professor Kloeffler discusses these developments in a thoroughly practical way that will interest the general reader as well as the student of telephony. Separate chapters deal with the different phases of the subject, from the details of the Transmitter and the Receiver to the more complicated apparatus of Intercommunicating Systems, the Strowger Automatic System, and the Panel-type Machine-switching System, which is that adopted by the American Telephone and Telegraph Company for the largest cities. The Feature Switchboard, which provides for machine ringing, automatic listening, secret service, and instantaneous disconnection, is fully described, as well as the protective devices that have been developed to meet the natural and artificial hazards which threaten injury to life and property or interruption to the service. A chapter on Multiplex Telephony gives a condensed account of the carrier-current principle, and shows the use of repeaters and filters in improving the quality of the sound transmitted.

Over two hundred photographs and diagrams illustrate the text, the circuit diagrams being an especially valuable feature for the electrical student. Professor Kloeffler has drawn on many sources in the compilation of this work, and we are indebted to him for gathering together in one handy volume many photographs of modern equipment and much useful information that have hitherto been available only in scattered pamphlets, periodical articles, and works by various authors.

KATHARINE MAYNARD.

Light, Photometry and Illuminating Engineering. By W. E. Barrows. First edition. New York: McGraw-Hill Book Co., 1925. 412 pp.

This book is a thorough revision of the author's former work entitled "Light, Photometry and Illumination," published in 1912. Since the chapters on the various classes of interior and outdoor lighting, constituting over half the book, are new, the author is perhaps justified in the use of a new title and the designation "first edition." Much attention has been given to modern lighting practice, and abundant illustrations accompany the text. The first third of the book is devoted to the physics and photometry of light. The author is Professor of Electrical Engineering at the University of Maine.

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Professional Notes

Activities of the Undergraduate Engineering Societies at the Massachusetts Institute of Technology

THE MECHANICAL ENGINEERING SOCIETY

At a recent meeting held in North Hall, the Society had the opportunity of listening to an especially comprehensive talk on the general trend of engineering by A. A. Potter, Dean of Engineering at Purdue University, who graduated from Technology with the class of 1903. Dean Potter dwelt especially upon developments in power generation, with which he was especially familiar due to recent service on the Prime Movers' Committee of the American Society of Mechanical Engineers. He pointed out the limitations on the development of water power, as at present there is no economical way of transmitting electrical power more than two hundred miles, this difficulty being due to corona losses. He presented figures showing that the steam turbine was greatly in the lead as a power producer, and noted that the sizes of turbine units were continually increasing.

Considerable interest was taken by the seniors in a recent trip which the Society took to the Blake-Knowles Diesel Engine Plant of the Worthington Pump and Machinery Company. The juniors enjoyed the same trip in January. The operations of manufacturing, erecting, and testing of the engines were inspected. Mr. Ziegler, who showed the group through, was kept busy answering numerous questions, which he did thoroughly and interestingly.

AERONAUTICAL ENGINEERING SOCIETY

Although escaping from a German prison camp may seem to lie more in the field of adventure than engineering, Capt. C. B. Willis proved that it was a major engineering feat when he described the experience at the Aero Society smoker on March 10. It was only after a year and a half of patient devising and making of a set of tools and supplies that the break could be attempted, and then it required the efforts of a hundred other prisoners in the camp to get a dozen of them safely through the guards and two sets of charged fences. A cantilever bridge constructed of bed slats and screws purloined from door hinges, a set of dummy wooden rifles that would click when "cocked," a set of flying grapples and a catapult to launch them, for the purpose of shortening the light wires, and a set of insulated scaling ladders all served their part in the escape. All twelve men cleared the camp, but only four of them finally made the 125 miles to the Rhine and the Swiss border. Captain Willis was one of them, and got back in time to get two more weeks at the front before the armistice.

The second speaker of the evening, Lieutenant Mac Short, told of the early days of Gypsy flying, when an airplane was still a curiosity and a flight an adventure. Out of the flying of those days, sometimes made desperate by small fields or the desire to take more passengers even after darkness or storm should have prevented it, was born the able, handy little touring plane of today. Though the Jennie and Canuck may be laughed at now, their history was a glorious one, and their never-ending ability to stand up season after season, and fly in all conditions, though only six or seven cylinders were popping, has earned for them an honored place in Aviation History and a secure one in the hearts of their pilots.

MR. THADDEUS MERRIMAN
Chief Engineer of the Board of Water Supply of New York, who addressed the Civil Engineering Society on March 4

CIVIL ENGINEERING SOCIETY

On February 17 a joint meeting was held under the auspices of the Boston Society of Civil Engineers, with Student Chapters from Harvard, Tufts, and Northeastern, at Chipman Hall, Tremont Temple. Mr. H. A. Hageman, of Stone & Webster, Inc., spoke on the Bartlett's Ferry Hydroelectric Development. The talk was illustrated with stereoptical slides.

On March 4 Mr. Thaddeus Merriman spoke before a large audience on "The Catskill Water System of the City of New York." Mr. Merriman is Chief Engineer of the Board of Water Supply of New York, and gave a most interesting lecture, well illustrated with slides. Mr. Merriman was much impressed by the interest shown. The project is of particular interest because of the large number of Tech men employed. Professor Crosby, of the Department of Geology, was associated with the work as geologist.

ELECTRICAL ENGINEERING SOCIETY

An inspection trip of the Edgar (Weymouth) Station of the Edison Electric and Illuminating Company of Boston was arranged by the Electrical Engineering Society on March 1, which was well attended. The visitors were taken through the entire station and shown the essential features of it.

Edgar Station is located on the Fore River in Weymouth and will ultimately cover an area of sixty-three acres.

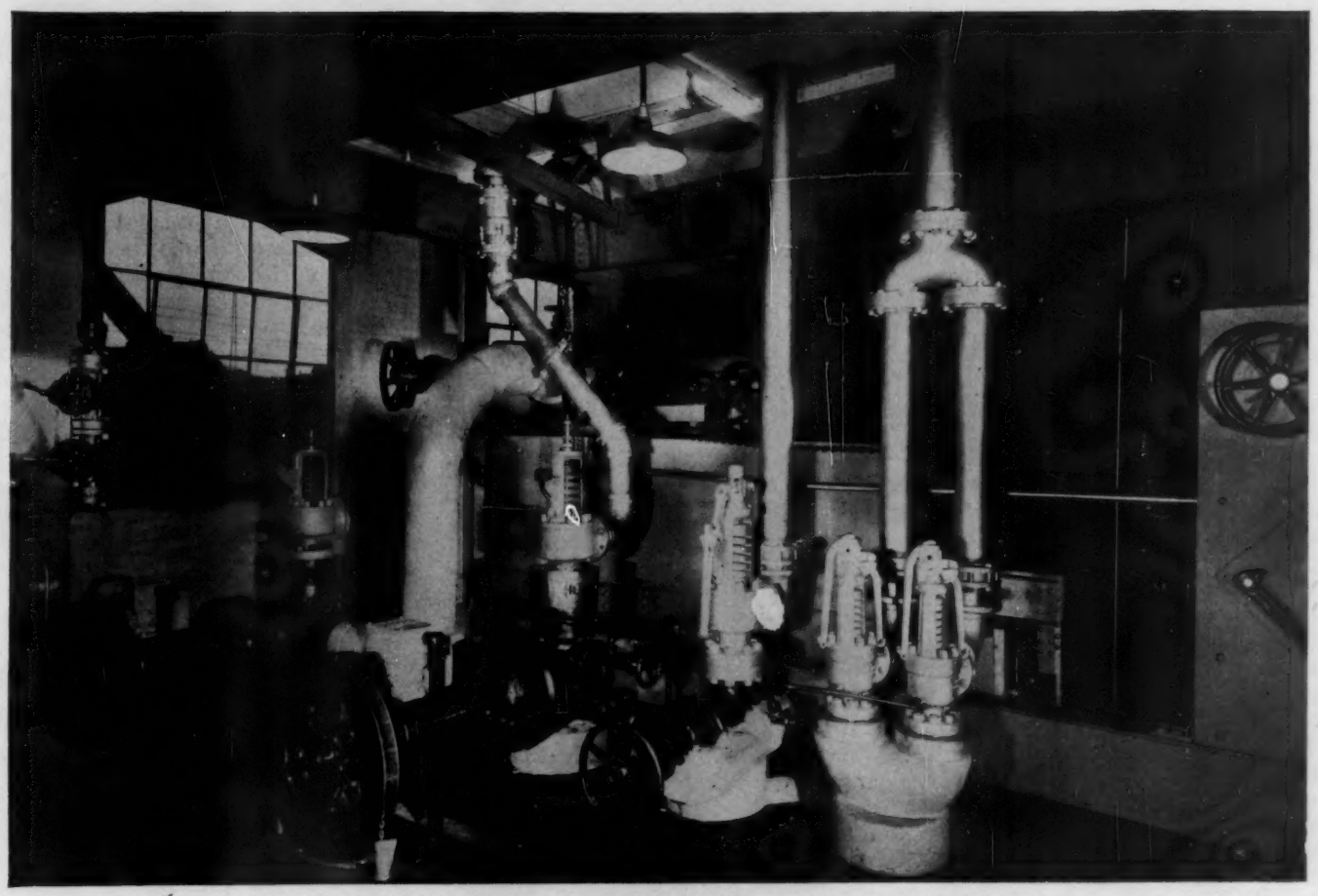
The turbine room is located adjacent to the water front with the boiler room adjoining it on the land side and lying between the latter and the switchhouse. The installed generating equipment consists of two 32,000 k.w. turbines, each of which drives a main 30,000 k.w. alternator and a 2000 k.w. auxiliary generator, direct-connected to the shaft of the main generator.

The turbines are supplied with steam at a pressure of 350 lbs., and an additional experimental unit of 2500 k.w. is installed operating at 1200 lbs. pressure and exhausting into the 375 lbs. system.

The boiler house contains three boilers of 19,743 sq. ft. heating surface, and designed for 375 lbs. pressure, and a boiler operating at 1200 lbs. pressure. All boilers are fired with electrically driven underfeed stokers.

Energy is generated at 14,000 volts, three phase, 60 cycles, and delivered to two buses. From there it is distributed through underground circuits. All equipment in the switchhouse is arranged to isolate vertically phases of all circuits. It consists of four stories and a basement. The basement contains test buses and a cable room for all incoming and outgoing circuits. The three floors above are occupied by switchgears, reactors, and buses. On the fourth floor are located the oil circuit breaker and disconnecting-switch operating mechanism. Each

(*Continued on page 94*)



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THE testing room shown above is located directly over the steam drum of the boiler, a general view of which appeared in the March issue. There are four nozzles on the drum extending into the testing room. Upon the right-hand one, as shown in the cut, are mounted two form DSE valves set for 1250 lbs., which comprise the regular safety-valve equipment of the boiler.

The second nozzle carries a specially designed cross globe valve for supplying steam to lower pressure testing drums. A form DSA safety valve is mounted on top of this to prevent any pressure above 300 lbs. entering this line. The third nozzle is used for testing valves under saturated steam. Upon this is mounted a 5-inch 1250-lb. non-scraping type gate valve on top of which is bolted the valve to be tested. This gate valve, which makes it possible to remove or disassemble the test valve while the boiler continues under steam, has a remote control by which it can be closed electrically from the boiler room floor.

The fourth nozzle carries the steam line to the superheater, and to the left of this is shown a valve being tested under superheated steam, this being mounted upon the outlet from the superheater with a 5-inch electrically operated gate valve placed beneath, exactly as in the case of the third nozzle.

By means of stop valves in the superheater lines and special dampers, the superheater can be cut entirely out of operation with the boiler when desired. The exhaust pipes from all the valves lead into a large Maxim Silencer above, for softening the sound of the steam discharge. A blower and exhaust ventilating system displaces the air on the gallery once a minute.

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BRIDGEPORT WORKS—CONSOLIDATED SAFETY VALVE CO.

X-Rays and the Structure of Metals

(*Continued from page 55*)

croscopic "needle" constituting a longitudinal portion of a microscopic fiber. Thus, in this naturally fibered material there is a definite orientation or lining up of the crystals with respect to a given axis. The effect is analogous to a bundle of wires held together in such a way that each is parallel to the longitudinal axis of the bundle. With the axis held at right angles to the line of vision, a regular arrangement is apparent; but with the axis parallel to the line of vision, the cross section view appears as a random array of spots.

Similarly, when the X-ray beam penetrates a fibered material perpendicular to the fiber axis, a diagram of the type shown in Figure 2 is obtained. On the other hand, when the beam penetrates parallel to the fiber axis the resulting diagram approximates that of a random arrangement of crystals (either a random array of spots, or concentric circles each of uniform intensity).

In metals subjected to plastic deformation, actual gliding of planes of atoms in those directions offering least resistance together with partial rotation results in a more definite orientation with respect to an axis along which stress has been applied. This externally applied stress may be of several kinds, among which may be mentioned mechanical, electrical, and heating or cooling stresses. Metals, having a simpler type of space lattice than asbestos, give a correspondingly simpler fiber diagram, which may vary greatly in degree depending on specific conditions.

Obviously, the immediate practical importance of "fibering" lies in the fact that it must inevitably impart directional properties to the metal, thereby increasing its non-homogeneity.

Internal Strains

The fourth type of information to be obtained from pinhole diagrams, i.e., the presence of strain (and probably of internal stresses) in metals, is of vital importance to the engineer, but thus far has proven very elusive to determine. Though still a somewhat disputed point among X-ray metallographic investigators, there can be no doubt that the pinhole method may, when fully developed, not only simply and satisfactorily indicate the presence of internal strains, but also serve as a means to determine relative variations in intensity of strain. The criteria on the diagrams are three—the extent of the fibering tendency, the presence of radial striations, and irresolution of diffraction images.

The first is obviously an indication, due to the mutual interaction of adjacent crystals on each other; the second is analogous to the elongation phenomenon in Laue spots resulting from the deformation of a single crystal; and the third is a direct consequence of broken up crystals and lattice distortion.

Before passing to the applications made in this laboratory, it should be emphasized that these types of pinhole diagrams are the same for all metals, the only differences being in the relative positions of the diffraction images which are characteristic for each metal.

Applications.

Cast Metals

Although it is commonly thought that cast metals generally exhibit a random orientation of grains, an examination of Figures 3, 4, and 5 show the great practical importance of the pinhole method in this field. The coarse, non-uniform grain mass (Figure 3) is by no means obliterated in standard commercial annealing processes as Figure 4 shows. The removal of internal stresses and non-uniformity is not impossible, as Figure 5 represents the structure of a portion of a casting similar to that shown in Figure 4. The pinhole method has proved to be a very sensitive detector of small differences in ultimate structure and relative magnitude of internal strain, which bids fair to make it an invaluable tool in the development of castings.

Worked Metals

Plastic deformation in metals tends to produce a condition of "fibering" in the crystals as described above. The degree of approximation to an ideal fiber diagram depends among other factors on

(1) The specific resistance of the material.

(2) The extent of working.

(3) The temperature of the material while being worked.

(4) Previous treatment.

Thus it is not surprising to find marked differences between hot and cold rolled metals. The rolling direction is plainly evident, for the rolling produces a decided lining up of the crystals denoted by the four symmetrical maxima. In the cold rolled samples the radial lines are much sharper, indicating much greater grain fragmentation and resulting internal strains. The exact mathematical analysis of the fiber diagram was thoroughly developed by Polanyi (Z. f. Phys. vol. 7, 1921). From such an analysis it may be demonstrated that these iron crystals tend to reach a final position in which one pair of the cube faces is parallel to the rolled surface, with one of the face diagonals parallel to the direction of rolling.

Annealing, being a process of recrystallization, accompanied by the relief of internal strains, can be closely followed by the pinhole method. Two specimens were taken from the same lot of annealed forming steel. The specimens showed no differences under the microscope, yet the X-ray substantiated the fact that one was satisfactory for forming operations, while the other was cracked. Obviously, the reason for failure was that annealing had failed to remove sufficiently the preferred orientation, i.e., the undesirable directional properties and strains caused by rolling.

Electrolytically Deposited Metal

The influence of electrolyte composition, presence of colloids, and current density on the character of the deposit are easily detected by the pinhole method of investigation. Figures 6 and 7 represent two specimens of electrolytically deposited lead. The only difference in the conditions of deposit was the presence of a minute amount of gelatine in the latter. The tremendous reduction in crystal size is at once apparent. The effect of varying current density on internal stresses in the deposit can easily be detected and studied.

Surface Studies

In order to study the differences between the surface and interior structure of metals, a method is being developed in which the pencil of X-rays strikes the sample surface at a grazing angle. The reflections are recorded photographically. The depth of penetration of the X-ray beam increases with the grazing angle. Apparently the outer surface is composed of exceedingly small crystals which scatter the X-rays rather than give definite diffraction rings. Correlation of surface structure with corrosion resistance is highly important for thin metallic sections used in aircraft construction.

Summary

After discussing the essentially crystalline structure of metals, the monochromatic pinhole method is presented as a most fruitful means of utilizing X-rays in the practical identification of casting, working, heat-treating, and electrolytic processes in metals. Surface as distinguished from interior studies are also described. Representative X-ray photographic diagrams for metals with different properties are

(*Continued on page 98*)

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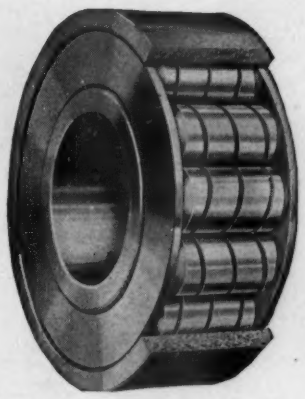

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The Technical Graduate in the Textile Field

(*Continued from page 51*)

ates employed in the textile industry? And by the technical graduate we mean the man who has come from an institution like Technology. For the present we will not include the graduate from a textile school. These men will be considered later. In the first class of plants cited, that in which the cotton fabric is manufactured and shipped in the gray state, we find but very few technical graduates. There is not the need of such a man, and in all justice to the non-technical men who are to be found in the mills, and without intending to disparage the technical man's ability, it is probable that the non-technical man is the better fitted for the job. The men who hold the executive positions of agents, superintendents, and overseers in such mills are men who have been in the mills since boyhood or from the high-school age period. They are thoroughly trained in the various textile processes of the departments, they are really specialists. They must be such, for the textile industry is like no other in one respect—the necessary training for carrying on the work cannot be acquired from books or in the technical school. It can only be acquired by actual experience in the mills, or to a certain extent in the textile schools.

Many of the mills are of medium size, some are small, and the salaries are in proportion. The number of high-salaried positions in such plants is small, and the technical graduate would not be attracted to these places even if he were fitted to carry on the work. The same condition exists in the smaller plants of those mills that finish their own goods, with the exception of the position of chemist. Every plant that bleaches or dyes its own cloth should employ a chemist. It is of great advantage if this man is a technical man, but here again he will be of more value to his employers if he has had mill experience.

In the cotton bleachery, dyeworks, and printworks, which are all included in the designation cotton-finishing plant, we find as a rule a larger number of technical men than in any other branch of the textile industry. These men are almost always chemists or chemical engineers, usually the former. The entire run of operations involves the use of chemicals or dyestuffs, and many problems of chemical engineering present themselves. Not only are the chief executives technical men, but many of the overseers will also be found to be such. The latter are men who later will be found in the managing positions. In one such large plant in New England, in the Manager's office, are four flat-top desks arranged in the form of a solid rectangle with the officials facing the center. These officials are the Resident Manager, the Assistant Resident Manager, and two assistants, the latter being the respective sons of the two former. Each of the four is a technical graduate in chemistry, and each started his work, after graduating, out in some one of the departments of the plant. Besides these men there are other technical men out in the works and in the laboratories. One might say that the plant was entirely in charge of technical men. Similar conditions, to a lesser extent, perhaps, will be found in all of the cotton-finishing plants of the country. Large salaries, as compared to those in textile mills in general, prevail, and the field is an attractive one. The number of such plants is not large, however, which fact naturally limits the number of available opportunities. There are always new colors coming out that have to be tested, new processes to be developed, and new effects to be produced, all of which calls for the education and ability of the technically trained man; but it should be noted that this work is done not as a rule in the mills that manufacture the cloth of which there are many, but in the finishing plants, of which, as we have said, there are relatively few.

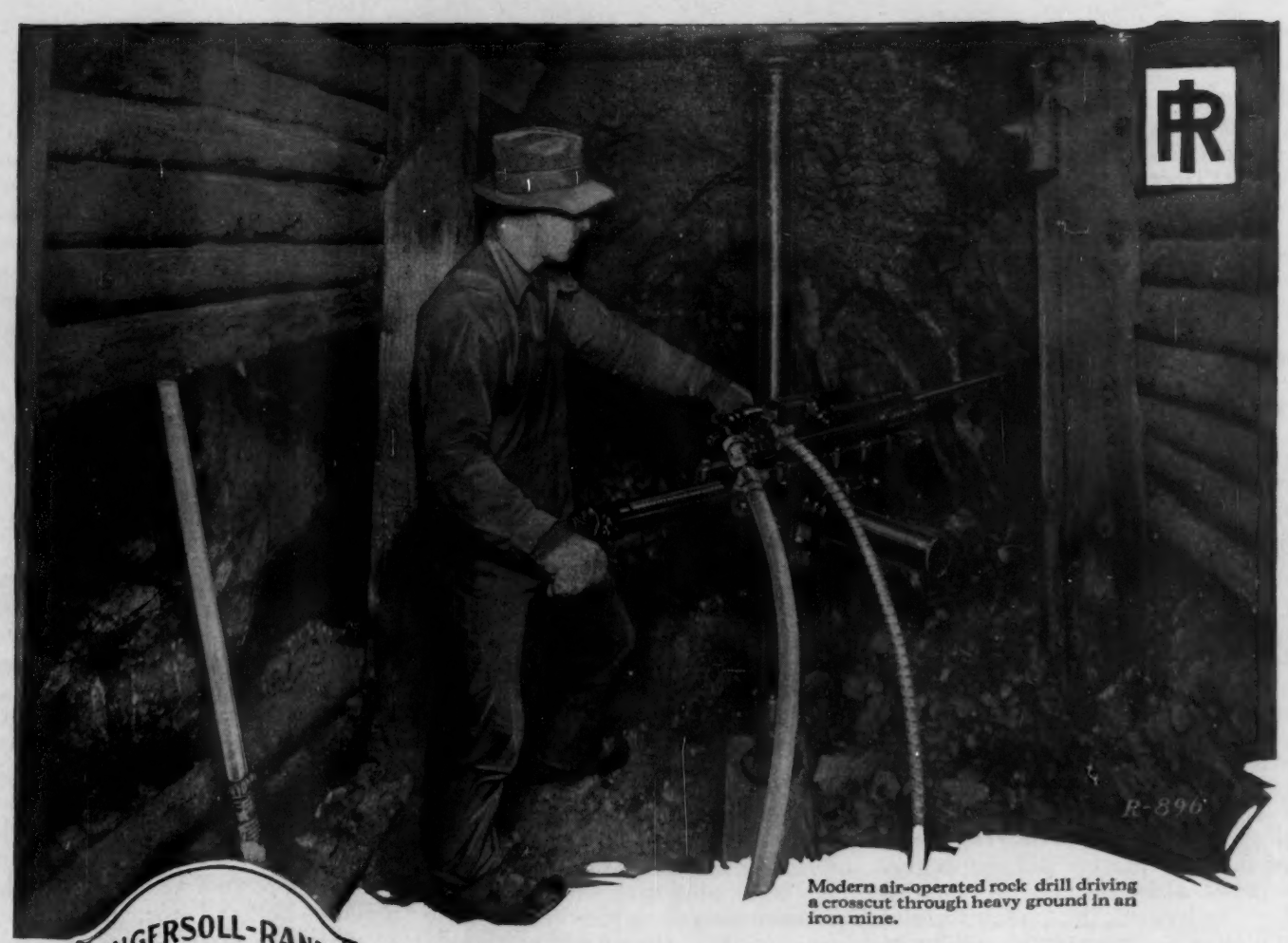
In contrast with the conditions that we find in the cotton-finishing plants are those that exist in the large woolen and worsted mills. Here, except in the laboratories, we find a marked absence of technical men. The department overseers are almost invariably purely textile men who have come up through the plant over long periods of years and who are super-specialists in their respective lines of work. They know how to scour, card, and comb the wool; how to spin the yarn; how to weave, dye, and finish the cloth. They may not know the theory of least squares, the characteristics of Carnot's cycle, or the formula of synthetic indigo; but give them a sample of cloth, and tell them to duplicate it in quality, weight, texture, color, and finish, and they can do it.

There is one exception often found, however, to this otherwise general condition. The heads of the Mechanical Departments in these large corporations are frequently technical graduates. These departments in the large mills are wide in scope, they are more than a "repair shop." The work carried on by them covers building construction and maintenance, machine design, construction and maintenance, the generation of steam and power, the trouble-shooting department (to use a crude but well-understood designation), and also, to a great extent, a development and research department. In the larger corporations particularly it is all-important, and the technical man is a valuable asset to the management.

If in using the designation of "technical graduate" we include those from the several textile schools in the United States, we must qualify much that we have already stated. The textile schools are sending out each year an increasing number of capable graduates, men who have had in the full day courses complete and detailed instruction in the technology of textile manufacturing and in the practical operation of the full-sized machines found in the mills. They have also had a considerable amount of general engineering training. There is another class of students, the night class, made up of young men who are employed in the mills during the day and who take up the specialized work in one or more of the textile processes in their part-time evening work. The graduates from these two classes are the men who are filling the positions in the textile mills today; and it can readily be understood why it is that they are better fitted for the work than the purely technical man trained in a school like Technology. There is a large amount of learning that the Technology man has acquired that he will never use in the textile mill, but that is not serious, because it will do him no harm to have that knowledge; but what is serious is the fact that he will lack much special knowledge that he should have if he is to follow the textile business. This knowledge the textile school graduate does have, and it can only be acquired either in this type of school or out in the mill itself. Here, by actual contact with the processes, the student learns the principles of manufacturing, the operations of the different machines, the characteristics and behaviour of the fibers, yarns, and fabrics involved, and the methods of obtaining the desired results. The four years of engineering or chemical training undoubtedly will enable the technical man to acquire this specialized knowledge more quickly and completely than the non-technical man, but not necessarily. Much will depend upon the personal equation of the man himself.

With the advent of Rayon, or the artificial silk fiber, there has come the need of the man with advanced chemical and chemical engineering knowledge to carry on the necessary

(*Continued on page 80*)



Modern air-operated rock drill driving a crosscut through heavy ground in an iron mine.

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Ingersoll-Rand

The Technical Graduate in the Textile Field

(*Continued from page 78*)

development work. One authority has stated that a Rayon factory is one huge chemical laboratory, since the various processes by which the silk-like fiber is produced from wood pulp or other form of cellulose involve complex chemical changes, and the operations must be carefully controlled to ensure a proper and uniform product. Rayon history is today in the making, and development is rapid. There are several marked and recognized weaknesses at the present time in some of the types of Rayon fibers, particularly the regenerated cellulose ones; and it is the task for the chemist to so improve and develop the forming processes as to eliminate these weaknesses. Here lies a large field for fruitful research. Some of the larger mills are taking up the manufacture of Rayon in their own plants, and if this is done it will, of course, call for additional technical men.

There does seem to be, however, an excellent opportunity for the technical man to take up the broader subjects of engineering as applied to textile mills, such as economy in combustion and in the generation and distribution of power, the reduction of wastes of power and steam, the improvement of lighting and atmospheric conditions within the mill, and the elimination of manufacturing wastes. The graduate's general engineering training will enable him to consider these subjects from various points of view and from many angles, and he will have a wide knowledge of the many points involved. There is yet much to be done on the development of proper methods of drying textile fabrics, of the proper insulation of dryers, and of the correct circulation of air within the dryers to obtain the greatest economy of drying combined with maximum production. There is much that we do not know concerning the injurious effect of high temperatures on the wool fiber. Are we permanently injuring and weakening the wool fiber by excessive heat in the various dryers of the scouring, slashing, tentering, and carbonizing processes?

In all of the processes concerned with the finishing of textile fabrics there is a great amount of steam used for heating, steaming, boiling, and drying. In a mill carrying on such work the fuel expense for the process part far exceeds as a rule that for power. This expense can be enormously reduced if such steam before passing to the processing is utilized in some way for the generation of power. By so doing only a very small portion of the contained heat will be removed, and thus the capacity of the steam for process work is but slightly diminished. In the meantime the power so generated will be obtained at but a fraction of the cost had it been generated by steam that was not subsequently used for process work. In other words, by making power a by-product of manufacturing steam very great savings in the cost of power can be made.

The day may come when in New England particularly no manufacturing wastes will be permitted to enter the water courses. When such ruling is made the mills must so treat the wool-washing wastes, the soap and spent dye liquors, as to remove the objectionable matter before the effluence is discharged into the streams. The problem will then be to make these treatments a source of profit. During the war potash was profitably recovered from wool-washing wastes, but today, with the present market price of potash, recovery with profit is impossible. The same is true of soap wastes. It is said that much of Germany's supremacy in industrial matters lay in her ability to profitably utilize her manufacturing wastes.

It is in obtaining exhaustive and accurate data along the various lines just cited (and others might be named) that the textile industry as a whole has not kept pace with other industries that have spent vast sums of money in learning all that could possibly be learned concerning their raw materials, their processes of manufacture, their finished products, and the profitable utilization of their wastes. Many machines and processes are the same today as forty years ago. The policy has often been to leave well enough alone; but things should never be well enough. There should always be progress. Much has come out during the past year in the textile press relative to the establishment of a Textile Bureau of Research, this Bureau to be supported by funds contributed by the textile concerns of the country. The results of the work accomplished would be available to all subscribers. Nothing definite has resulted, however, but it is hoped that the project will not be abandoned. It has much to recommend it.

Within the past month it has been announced that some English chemists have been investigating the weakening effects that the damp atmosphere in tropical and semi-tropical countries has upon fabrics made of wool. They have found that these results are due to a bacterial growth that tends to liquefy the outer scales of the wool fiber and to make the gelatin-like substance soluble. The problem then becomes one of finding some substance with which the fabric can be impregnated that will make it proof against bacteria. Here is an excellent task for the bacteriological department of the Research Bureau. Fabrics are now rendered moth-proof, so why not bacteria-proof?

The desire in this article has been to emphasize the point that an attractive field for the technical graduate lies in the textile industry today, but that it lies in the broader application of modern and economic methods for the conservation of fuels and other raw materials, the reduction and elimination or profitable conversion of manufacturing wastes, and the reduction of manufacturing costs. These three matters are all interconnected—attainment of one will help to attain another, and so on. It is in such fields rather than in the manufacturing proper that the opportunities for the technical graduate lie. No other industry is so at the mercy of the whims of fashion as is the textile industry. Competition is keen and margins of profit must be scaled to the lowest limit in order to get the business. In a press report issued a short time ago, along with the annual statement of one of the largest cotton and wool manufacturing corporations of the country, it was stated that the saving of one half of a cent per yard on the cost of the year's product would have changed a considerable deficit into a good-sized profit. What an opportunity for a man, be he technical or non-technical, textile or non-textile, to endeavor to bring about the saving of that half cent or even a part of it!

If the non-textile technical graduate does decide to enter the textile industry, and wishes to make the most of the opportunities offered, then he should be prepared to spend some time, the longer the better, in learning the principles and practical part of textile manufacturing, as preliminary to the application of his more advanced technical knowledge. This he can do at the beginning of his employment, but a better way is to acquire this knowledge during the summer-vacation periods of his undergraduate years.

Always marked with the "Diamond"

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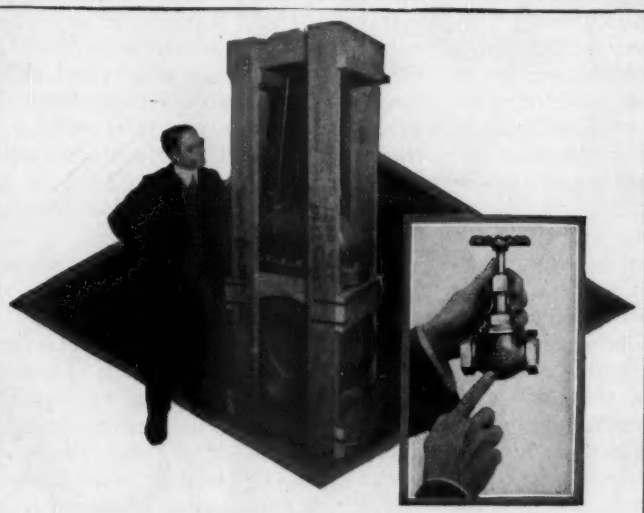

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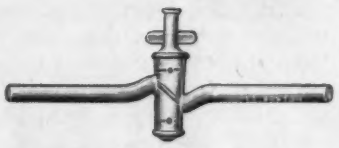

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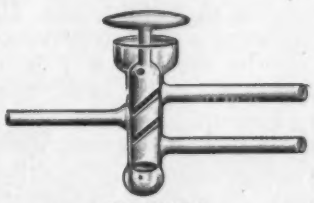

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SINCE 1895

Engineering Measurement Standards

(*Continued from page 52*)

ardization is simplification and reduction of variety in order to secure the economies of greater volume with less inventory in finished parts, production tools, and raw materials. As an indication of what may be accomplished in this time, the experience of a plant manufacturing typewriters should be of interest. A survey revealed the fact that over two hundred different designs of screws of various types and sizes were used in the product. With a little study it was found to be possible to reduce this list to about eighty different types and sizes, thus increasing the unit production and reducing the variety, with the resulting economy that follows greater production. Even when conditions do not permit the use of standard finished sizes, a great deal can be accomplished by careful attention to the size and nature of the raw material to be used; the object here should be to use the same size of stock for as many different pieces as possible, thus reducing the variety of stock which is another source of economy.

The third stage of standardization is the formulation and adoption of general engineering standards for use in all manufacturing plants. These standards are usually a selection from existing shop standards. Their general use secures the economies of co-operation by creating a wide market for standard tools and manufacturing equipment. The larger the market for these tools, the greater the volume of their production, and the less their cost. In addition, the general adoption of many of these standards has led to the creation of plants specializing in their production, thus making it possible to purchase many such standard parts cheaper than they can be manufactured in smaller quantities.

The formulation of these general engineering standards is a very interesting process. Until a few years ago, this work was done by various engineering societies and trade associations, each devoting itself to its own particular field and needs. Naturally under these conditions, with no definite method of co-operation, there were many occasions where the activities of one organization overlapped those of another. In order to eliminate this undesirable feature, the American Engineering Standards Committee was organized. This committee is supported by practically all of the important engineering societies and trade associations, and directs the formulation of these general engineering standards by making certain that all interests involved in any given project are adequately represented. The formulation of such standards is similar in many respects to legislation, and the present procedure is as follows:

A subject for standardization is proposed. A group of interested people is called together by this committee to discuss the need of the proposed standardization, the different interests involved, and the general scope of the proposed project. If this group reports favorably upon the project, the next step is to select the most interested engineering societies and trade associations to act as sponsors for the work. A special committee, known as a sectional committee, is then formed of persons best posted on the particular subject. These representatives must come from three general groups — manufacturers of the product in question, users of this material, and general engineering interests who are neither manufacturers nor users. No single one of these groups can have a majority on the sectional committee.

The sectional committee is then called together, organized, and their study of the problem begins. The effort is made to select from existing practices and shop standards rather than to formulate something new. The subject is discussed from all angles, its production, use, and any engineering features that may be involved. Sometimes the available information is so incomplete that definite investigations, or researches, are made by several of the most interested organizations to obtain data on which to base the recommendations. The specifications as finally formulated must have practically the unanimous support of the members of the sectional committee before they are submitted to the sponsor bodies for approval. Most of these sectional committees spend at least two or three years, and usually more, before completing their program. Sometimes after several years' consideration they are unable to report any mutually acceptable solution, and the subject is dismissed for the time, it being evident that under such circumstances this particular subject is not ready for standardization. Such a condition usually exists under one of two circumstances: First, when the available information is incomplete or conflicting. In such cases, definite research is usually undertaken to clear up the questions, and the standardization activity ceases until these researches are completed. The second circumstance is when quite different manufacturing processes are involved in the production of the material in question, and the specifications which satisfy one method of manufacture are unsuitable for the other manufacturing methods. Here, unless one particular method is pre-eminently superior to all others, little can be done until either the different processes have been developed to produce similar results or the product itself has been developed so that it can be produced by all different methods. This also involves considerable research.

Oftentimes a selection must be made between several good practices. In this case, where all practices have about equal merit, the one most widely used is selected as standard. Thus the selection of one practice as standard does not necessarily mean that the discarded ones are without merit. In such cases, it is most expedient to select the one most widely used, because uniformity can thus be attained with the least disturbance. Expediency often plays a large part in the selection of many standards.

These sectional committees do not adopt standards. They formulate and submit them to the sponsor bodies for their approval. These sponsor bodies are charged with the responsibility of reviewing these recommendations from an engineering viewpoint and adopting them as standard. These sponsor bodies alone have the legislative power, and finally adopt or reject the proposed standards.

After a standard has been adopted, it is promulgated by the interested sponsor bodies. The general use of these standards is not a matter of compulsion, but of common consent of the manufacturing public. In the final analysis, the success of these standards depends entirely upon their own intrinsic merit. If these standards are good, they will eventually be widely used. The greater their use, the greater the resulting economy, which in itself exerts a powerful influence on even more widespread use. Considering the effort that is put forth in the formulation of these standards, however, the evidence should be strongly in favor of their intrinsic merit.

Standardization is a subject that should be given careful study by all engineers engaged in design. It is a primary source of economy in all of its phases — individual product standards, shop standards, and general engineering standards. Careful consideration should be given to existing standards, and these should be employed unless there is a sufficiently valid reason to depart from them. It

(*Continued on page 90*)

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TIMKEN *Tapered Roller* **BEARINGS**

Problems of Railroad Management

(*Continued from page 53*)

The period which has followed has been one of revival and recovery, slow and hesitating at first, but finally gaining unprecedented force, and in the last three years sweeping our transportation systems on to the greatest achievements of their history. In this they have been immeasurably aided by the rapidly growing friendliness of public sentiment, which increased by leaps and bounds since the war, and bore its first fruits in the constructive features and the generally helpful spirit and intent of the Transportation Act of 1920. The American public has unmistakably registered its will that railroad regulation shall be conducted for the purpose and object of giving us better railroads and more efficient transportation, and that harsh and restrictive regulation, or regulation for partisan ends, which defeated such purpose and object, shall cease.

The regulative authorities, themselves, are taking an important place of leadership in this re-casting of public opinion. As the Interstate Commerce Commission is constituted and functions today, it represents a genuinely constructive and encouraging force and influence on the side of railroad progress.

The recent achievements of our railroads, and particularly those of the last year, may be regarded as a fair indication of what can be accomplished in a more sympathetic and helpful atmosphere. Important new records for excellence and efficiency of service were created in 1925, while at the same time the railroads handled the greatest volume of freight traffic in history, measured by loaded revenue cars, with no car shortage and virtually no transportation difficulties.

A clearer understanding of the problems of mutual concern to the railroads and their patrons was certainly one of the factors contributing to these good results. In this field, the Shippers' Regional Advisory Boards, formed in the various traffic regions of the country, have been most active, and their work has been in the highest degree beneficial. These Boards form a common meeting-ground for shippers and railroad officers to analyze the transportation needs of the territory involved, and assist each other in anticipating car requirements and promoting the most advantageous distribution and use of available equipment. The work of the Boards is sure to be increasingly helpful in the future.

Although problems arising from the relations between the railroads, their patrons, investors, and the regulating authorities are of vital consequence, they cannot transcend in importance those arising from the relations between the railroads and their employees. In fact, industrial peace in the transportation field is a pivotal requisite, because without such peace a solution of the other problems of railroad management would be futile.

We believe that in this field the employees and management of the Pennsylvania Railroad have been particularly successful, in addition to being pioneers. Our Plan of Employee Representation, as we term it, has been in operation five years, and as a practical working method of establishing and maintaining co-operation, loyalty, and confidence between management and men it is an accomplished fact. It is a plan for settling peacefully, and by joint action, all questions that mu-

(*Continued on page 86*)

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View showing construction of Cottage Farm Temporary Bridge in Charles River Basin, completed October 2, 1923

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INDUSTRIAL BUILDINGS SHOULD BE WELL LIGHTED.

From the employer's viewpoint, the big difference between men who work out of doors and those who perform tasks inside the building, is the factor of light. Daylight furnishes sufficient illumination outside during the daytime working hours for men to pursue their tasks efficiently and safely. But the proposition of getting enough daylight into the interior of industrial buildings, requires some thought.

It is not a difficult problem by any means, and any employer can take advantage of daylight and utilize it for lighting his building during the daytime, if he desires. It is an excellent light, especially suitable for the eyes, reducing eye strain and eye weariness to a minimum, and has the great economic advantage of costing nothing.

To utilize daylight to the utmost, we must first provide means for allowing daylight rays to enter the interior of buildings in sufficient quantity—namely, proper and adequate windows and skylights. Many excellent instances of buildings designed with a due regard to the importance of daylight lighting can now be seen in many of our industrial cities. Such buildings present the appearance of being practically all windows—"window walled," as they are termed—and this type of daylight construction is coming rapidly into favor, because it constitutes a more healthy building for large numbers of employes, both from the lighting and ventilation standpoints.

Among those who have constructed this type of modern industrial building may be mentioned: The Shredded Wheat Co., Gillette Safety Razor Co., Lyon & Healy Piano Co., H. J. Heinz Co., Corona Typewriter Co., Skinners Macaroni Co., Grape Juice Co., Dodge Bros., Nelson Valve Co., Piston Ring Co., Remington Arms Co., and a great many others.

The Larkin Co., Philadelphia, has erected a building almost entirely glass, 85% being windows, and the Loomis Breaker, operated by the D. L. & W. R. R. Co., Nanticoke, Pa., is literally a glass house, being 93.5% of glass. The new buildings of the Winchester Repeating Arms Co. have an average glass area of 58%.

An investigation covering 18 buildings constructed by the Aberthaw Const. Co., Boston, shows that the average window area is 57.5%.

These figures indicate how important the subject of lighting is now considered by employers of industrial labor, and how well the idea has been carried out by the architects and engineers, in order that all parts of a building may receive sufficient daylight. But, in addition to providing ample window space, there is another factor which is equally important, and that is, equipping the windows with the proper glass.

The bright direct rays of the sun should not be permitted to strike the eye, and we must provide a means for reducing the glare to rays which will not be too bright. This is accomplished by glass especially manufactured for industrial windows, known as Factrolite. This glass possesses the property of breaking up the intense rays of the sun and diffusing the light into the interior of the building in proper portions, solving the problem of sun glare.

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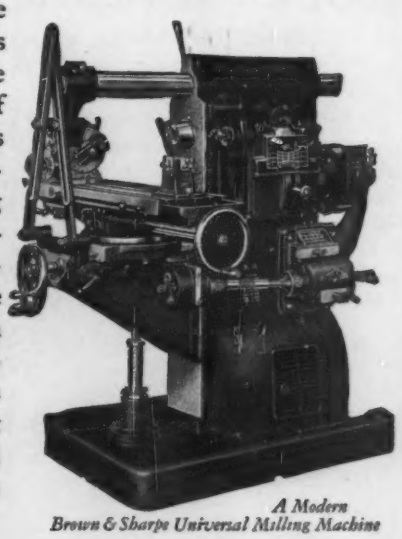
A Machine that lightened man's burden of toil

BEFORE the middle of the nineteenth century much of the work done in the metal working shops was hard, slow hand work. The results were rarely accurate. A striking example of these toilsome methods was the making of twist drills. Until 1861 *the flutes were filed in the drills by hand with a rat-tail file!*

An increased demand for drills in 1860 spurred the inventive genius of Joseph R. Brown, one of the founders of the Brown & Sharpe Mfg. Co., and in 1861-2 he built the Universal Milling Machine. Spiral milling was at last made possible, and the flutes of the drills were milled on this machine accurately, at a tremendous saving in time and, especially, labor.

Hundreds of other uses were soon found for this remarkable machine. It has relieved the machinist of much toil as its usefulness increased along with its continual improvement. The modern Brown & Sharpe Milling Machine is one of the most versatile of all the machine tools.



A Modern Brown & Sharpe Universal Milling Machine

BROWN & SHARPE MFG. CO.
PROVIDENCE, R. I., U. S. A.

Problems of Railroad Management

(*Continued from page 84*)

tually concern employees and management. Under it, properly designated officers, together with representatives of the employees in each craft, chosen for that purpose from among their own number, gather around a conference table as friends and partners to discuss and decide together the problems of wages, working conditions, discipline, and other matters concerning the welfare of the employees and their relations to our railroad enterprise as a whole. We do not make the assertion that we have achieved perfection, but results thus far have been so encouraging that we feel the right chord has been struck, and that we have mutually worked out a practical system of collective bargaining within our own ranks.

Of somewhat different character from the problems thus far discussed are those arising out of the advent of the new forms of transportation which have been developed in the last two or three decades—the motor vehicle and the airplane.

It is doubtless true that for many purposes motor cars are capable of furnishing short distance transportation to better advantage and with greater economy and efficiency than by rail. The public is, however, coming to the realization that the motor car's true function, especially as a commercial carrier, is chiefly as a feeder to the railroads, or as a connecting link between the existing rail lines. Save in rare instances it is, and must indefinitely remain, a far less efficient, less satisfactory, and less economical instrument than the railroads for long distance or bulk transportation of either passengers or freight. The real problem between railroads and motor cars is not one of competition but of co-ordination.

Air transport, as a commercial enterprise, is still largely an unknown quantity. It would seem, however, that its commercial development in the passenger field will, for at least a long time, be confined to de luxe service, for people willing to pay high rates in return for exceptional speed and the novelty and distinction of a mode of travel open only to the few. As a carrier of goods, air transport is quite likely to develop on a considerable scale in the field of high-class mail and express, and perhaps certain forms of very valuable freight. In all of its aspects, however, it seems to promise the creation of a new super-luxurious transport field of its own, rather than to threaten, at least at any early period, a very serious invasion of the fields already occupied by the railroads.

One more problem of railroad management deserves mention in this necessarily very brief review. It is the problem of railroad consolidations. Its solution involves considerations of far-reaching consequence.

The proposal to consolidate our American railroads, now embracing several thousand corporations, into a comparatively small number of large systems, is one with which railroad executives generally are in complete sympathy so far as broad principles go. The only room for genuine difference of opinion lies in the methods to be pursued.

As a matter of fact, railroad consolidations have been going on for a long time, and have progressed much further than is generally realized. At present, there are twenty-two major railroad systems which handle eighty-five per cent of all the traffic of the country. Had it not been for the restrictive provisions of the Federal and State anti-trust and anti-merger laws, the great majority of the other lines would undoubtedly by this time have gravitated quite naturally into these large systems, which in their turn could have adopted greatly simplified corporate organizations—all with resulting advantage to the country from every point of view.

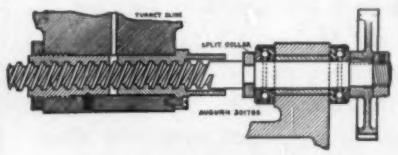
What railroad executives and managers fear and oppose, however, is any movement looking toward putting consolidations into effect on an arbitrary or forced basis, or toward penalizing intelligently planned, conservatively financed, and properly managed railroads by compelling them to bear the burden of losses incurred in operating lines not so planned, financed, and managed, and some of which perhaps should never have been constructed at all.

President Coolidge has expressed himself soundly on this entire subject by advocating voluntary and permissive consolidations with the encouragement and assistance of governmental authorities, and subject to Federal approval to guarantee protection of the public interest. The Interstate Commerce Commission itself has endorsed this general view, and new measures recently introduced in Congress should provide a practical means for putting it into effect.

These developments serve to indicate how notable is the extent to which sentiment in regulative and other governmental circles is swinging away from theories of arbitrary and compulsory consolidation, and toward the idea of leaving the railroads a relatively free hand, at least for a reasonable period of time, to work out the solution of this important problem along natural lines and in accordance with business and economic principles.

Such a change in sentiment upon so fundamental a question may in a sense be regarded as culminating evidence that the spirit of railroad-baiting, which burned so fiercely for more than thirty years, is finally flickering out, never, we hope, to be rekindled. If this view is correct, there has never been better reason than at present for sound optimism and confidence regarding the railroad future.

New High-Power Laboratory. The Westinghouse Company has recently put into operation at East Pittsburgh a new high-power testing laboratory which will enable extensive tests to be made on oil circuit-breakers which formerly could be tested only on power systems. The laboratory will also be available for completely testing large alternating-current generators, synchronous condensers, and frequency converters.—*Power*.



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Foreign Telephone Systems

(*Continued from page 56*)

The Compania Telefonica Nacional de Espana obtained its concession from the Spanish Government in August, 1924. This company was organized in co-operation with a group of Spanish bankers, and was financed mainly through the sale of preferred stock through the Spanish banks to Spanish investors.

The work now going on in Spain is of particular interest, both in view of the obstacles to be overcome, and the magnitude of the program which has been mapped out. The first problem with which the company had to deal, while plans for the future were being worked out and materials obtained for carrying them through, was to devise and execute emergency measures to tide over the unavoidable interval until fundamental plans should begin to take tangible shape. As far as possible this emergency work has been done in such a way that the plant so added will constitute a preliminary factor in the solid structure which is the ultimate objective. But even so it was necessary to string new overhead cables in certain places where the fundamental plans call for an underground layout, in order to meet current service requirements.

The Spanish construction program is formulated to meet an intensive development within the next ten years which will increase the number of telephones in Spain from the present figure of 92,000 to possibly over 400,000, operated in conjunction with a genuinely nation-wide long-distance system that may be fairly considered the equal of any in the world. It includes the installation of automatic central offices in nineteen cities, the placing of all cables underground in the larger cities, the construction of new long-distance lines, the installation of repeaters on existing lines so as to raise the quality of transmission to a high standard, and the use of carrier-current telephony where necessary on congested routes until additional lines can be built.

At this writing, repeaters have already been installed, or are in process of installation, in seventeen cities. As the construction of new long-distance lines progresses, many places will be provided with telephone connection which heretofore have not enjoyed this advantage, and all along the long-distance routes, old as well as new, small exchanges are being opened in villages which up to now have had no local service.

At the same time the local cable systems of the big cities, such as Barcelona and Madrid, are being replaced and reinforced to take care of immediate needs, and placed underground as fast as possible.

In addition to the problem of making fundamental plans for the expansion of the physical plant, and providing temporary facilities to relieve the present urgent need, the new Spanish company was faced with another problem, no less difficult of solution, and requiring wide experience and sound judgment to handle, namely, the question of personnel.

It was necessary to take over a variety of different administrative and operating organizations—some formerly employed by the Government, others the employees of local companies whose franchises were acquired—and weld them into a harmonious machine for the operation of a nation-wide system. In addition to this there was the problem of securing and training the technical workers needed to carry out the extensive program of new construction which the company had planned.

In this phase of the work the International Telephone and Telegraph Corporation again rendered invaluable assistance by sending men with long experience in the various phases of telephone work to assist in organizing the different departments of the Spanish company. Schools for the instruction of employees in their duties are being conducted in Madrid and Barcelona, and in these cities there are also schools for cable splicers and for engineers and their assistants. The cable splicers' schools are of particular importance, because the art of cable splicing is one which it requires considerable practice and application to learn, and also constitutes the fundamental and all-important operation in the construction of telephone outside plant.

Among the projects which the Spanish company has carried out since its inception was the laying of a submarine cable across the Strait of Gibraltar, a distance of eighteen nautical miles, and the circumstances attending this work are of sufficient interest to warrant repetition of the story.

In view of the situation in Morocco, the Spanish Government was particularly anxious to have telephone communication across the Strait, and when the concession was granted, late in August, 1924, one of the conditions imposed was that such communication should be established before the end of the year. Owing to the exigencies of the situation, and the time required to obtain a new cable, arrangements were made for the temporary use of a Government submarine telegraph cable. That was dedicated to service on December 1 by a conversation between His Majesty King Alfonso XIII and General Primo de Rivera, the former speaking from Madrid to the President of the Directorate, who was then in command of the Spanish forces, in Tetuan, Morocco.

But although this makeshift supplied the demand for official communications well enough in the interim, the company kept its word, and laid its own cable from Algeciras on the southernmost point of Spain, to Ceuta, on the opposite side of the Strait of Gibraltar, before the end of the year.

On the 12th of December the cable left England on a merchant ship, and on arrival at Gibraltar was deposited in the specially built tanks where spare sections of cable are kept always wet. The cableship *Amber*, which was to lay

(*Continued on page 90*)

CRANE VALVES

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In daring, imagination and originality no other country has produced the equal of the engineers trained in our American technical colleges. A definite part of the Crane service policy is to anticipate the achievements of the nation's future engineers. Crane men everywhere are always glad to exchange ideas with students and instructors. Contact with you undergraduates is always welcomed. In 103 major cities of the United States, Crane has established Exhibit Rooms where valves, fittings, and steam specialties are on display.

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Measurements

(*Continued from page 82*)

should always be realized that exceptional conditions require special consideration. Also that standards are evolved to meet the usual or average conditions. No standard should ever be used unless it meets the peculiar requirements of functioning, service, and economy as well as, or better, than any other construction. The exceptional condition is rare, however, and it should definitely be proved to be present before departing from existing and accepted general engineering standards.

Foreign Telephones

(*Continued from page 88*)

the cable, was just then engaged in an attempt to locate trouble in a telegraph cable off the coast of Portugal, but she made port on Christmas, and two days later was ready to undertake another voyage, and loaded the telephone cable into her hold.

The shore-end was landed at Algeciras, and made fast at the cable terminal hut overlooking the beach. Owing to threatening weather the cable was cut, and anchored to a marker-buoy a couple of miles off shore. The *Amber* then proceeded to Ceuta, where the other shore-end was laid in a driving rain at night, with the aid of a powerful searchlight on the ship's bridge. Early the next morning the *Amber* set sail from Ceuta to lay the deep-sea section of the cable. The final splice was accomplished on deck, and the testing ended in complete success—with the year 1925 still a day away.

Space does not permit a detailed account of the work being carried on in Mexico, where a new long-distance franchise and a modification of the existing local franchises were obtained last summer. Suffice it is to state that the problem in Mexico, from a technical standpoint, is very similar to that encountered in Spain, and that it is being met with the same careful thought for the development of future years, together with a vigorous program of construction to meet the immediate pressing needs.

As regards telephone development in general, enough has been said to show that, while the art is still in its infancy, it nevertheless shows promise of growing into a veritable giant, who ere long will bestride the world, stretching out his web of copper threads unto the uttermost parts of the earth, that all men may be neighbors, having spoken intercourse at will, irrespective of any divisions either natural or political.

Welding with Atomic Hydrogen. The use of atomic hydrogen with the electric arc is a recent and very important development in the welding industry. The operation of such an arc is very interesting, and its advantages are worth noting.

Pure hydrogen is blown from a nozzle around an ordinary electric arc. As soon as it is heated to the high temperature of the arc, it becomes dissociated from hydrogen molecules (H_2) to hydrogen atoms (H), at the same time absorbing a great amount of heat energy from the arc. At a short distance from the arc the atoms recombine to form molecules giving off this surplus heat. This action occurs at the surface of the object being welded, since the hydrogen is blown from the jet in that direction. It is also aided by the catalytic action of the metal, which causes a more rapid molecular formation and consequently a greater intensity of heat given off. The atomic hydrogen is very active, and it combines with any oxygen in the arc or on the surface of the metal being welded so that an extremely ductile weld is obtained.

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Metal Display Rack

Designed to Display Confectionery

It is made of Sheet Metal, finished in attractive colors, with Card Holder in front.

Display Stands can be designed to suit nearly all products sold in Retail Stores.

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In April, for instance, there is an article by E. H. Johnson on "Blasting Coal for Mechanical Loading," which covers this subject clearly and thoroughly. Those interested in hard rock mining will find in "Mining Methods of The Cresson Gold Mining Company" some practical explosives data. The construction engineer of the Queenston-Chippewa hydro-electric canal tells about that unusual project which, when completed, will utilize a part of Niagara's wasted energy. "Mining for Oil" describes a new process of extracting petroleum from oil sands. And, of course, a Blaster Bill cartoon and the usual bibliography of all articles on drilling and blasting and a list of new patents, digested from the technical press of the world.

Our new subscription rate—*Three Years for One Dollar*—is less than might reasonably be asked, but professors tell us they would like to have their mining and engineering students read The Explosives Engineer regularly. Therefore, we have gone as far as we could to encourage this.

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Electrical Railroads

(*Continued from page 61*)

desired to utilize the full benefit of the steam locomotive. The speed of this type of engine can be adjusted to conform to the speed of the steam engine, and thus maximum help from the steam engine secured, the electric locomotive itself operating at full load. Operating by itself, it has the speed characteristics and the ability to adapt itself to all changes in the profile, and, if constant speed is desired, or is an advantage over certain parts of the section, this type of locomotive can easily operate utilizing the motors as shunt motors in the obtaining of constant speed. With this type of control it has constant horsepower characteristics enabling the locomotive to develop its full capacity under a variety of speed and tractive effort conditions.

The arrangement for regeneration is most simple, and is such that the locomotive has the ability to regenerate at any speed from the maximum to practically a stand-still.

One may ask what are the possibilities of electrification. Results actually obtained with existing railroad electrifications have convinced, I believe, railroad executives and their organization of engineers and operating officials that electric motive power is available today which will meet the requirements of practically all classes of railroad service, and that electric operation has proven more dependable and more reliable than the steam operation it replaced.

Capital expenditures, however, are needed to gain the benefit of electrification. In the study of benefits to be gained, too much attention should not be given to the percentage return in dollars and cents on the capital investment. Electrification is in the nature of a major improvement, as is double tracking, or the building of cut-offs, and strengthening of bridges, either one of which is to obtain better and more reliable operation together with increased track capacities—which after all is the real return gained from any major improvement.

The question of power supply has been one of the troublesome questions to the railroad people. Not only is the building of a power house a very large item in the total cost of any electrification project, but in the operation of this power house the railroad organization must enter a field which may not be entirely familiar to their operating staff.

The present tendency of the power companies to look with favor upon a railroad load should be of the greatest interest to railroad men. With the power companies ready to develop and furnish to the trolley wire the energy required, owning and controlling the transmission lines and substations which may profitably to both parties be on the railroad's right-of-way, advantages due to electrification can be more easily obtained.

Electrification is far greater than the mere substitution of one kind of motive power for another, even if the costs are less to operate. Electrification will come due to the possibility of so increasing the output and efficiency of the whole railroad, including plant, tools, management, and men, as to more than offset the increased capitalization necessary for its installation.

Open House

(*Continued from page 63*)

electric turning lathe and a band saw. With advanced problems he is free to work out his own ideas for the proper production of any required piece.

The Radio Station IXM is also in the Foundry Building, and students in charge will welcome interested visitors.

As a finish for the evening the visitor may inspect the Walker Memorial, presented by the alumni to the students in honor of President Walker. All the activity offices will be open, and copies of the publications will be on display. The visitors are welcome in the student libraries and game rooms. The large Main Hall, with its beautiful mural painting, and the dining and social halls will be open, and after passing through the Trophy Room the guest may inspect the Gymnasium on the top floor. At 11.00, the Chemical Warfare unit of the R. O. T. C. will stage a demonstration of the use of smoke screens and hand grenades to cover infantry attacks. The attackers will be harassed by tanks, and the whole scene will be illuminated with brilliant magnesium flares and star-shells. F. T. KURT, '27.

Advanced Calculus. A course arranged with special reference to the needs of students of applied mathematics. By Frederick S. Woods. Boston: Ginn & Co., 1926. 397 pp.

In this book Professor Woods has embodied the course in advanced calculus which he has given here at the Institute for many years. The students to whom the course has been given having been chiefly interested in the applications of the calculus, the course is not one in analysis; yet because of the necessity for some knowledge of theory, the author has introduced his readers to theoretical questions, partly with the hope of inciting some to more thorough study.

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The most efficient manner of handling sawdust, shavings, kindling wood, wool, rags, rubber, and most loose materials.

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CIRCUIT I-T-E BREAKERS

PROTECTION!

MANUFACTURERS of motors and generators formerly took the stand that the staunch construction of their apparatus rendered protective devices unnecessary.

Now they know that there is a limit to the life of even the best built motors or generators—that *overloads* and *short circuits* are destructive and costly.

Industrial engineers and executives have found it far cheaper to give their equipment the finest protection available rather than trifle with inadequate forms of protective devices.

I-T-E Circuit Breakers have, for almost 40 years, been giving electrical machinery and power circuits the *right* kind of protection—insuring such equipment—every minute—every day—year after year—against burn-outs and destruction.

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8 U-RE-LITE I-T-E CIRCUIT BREAKERS

Professional Notes

(*Continued from page 74*)

bus section is in a room by itself, a concrete wall separating the two sections.

All generator and feeder circuits are connected to the bus through two oil circuit breakers in series, both breakers being able to open the circuit under any emergency condition.

The operating room adjoins the oil circuit breaker mechanism room, and a conduit room is located right below the operating room on the third floor. All station auxiliaries are motor driven. Motors of 25 h.p. and less are served at 550 volts A.C. and those of greater capacity at 2300 volts A.C.

Essential auxiliaries are supplied from auxiliary generators driven by the main turbines. Provision is also made to supply these auxiliaries from the main bus. The less important auxiliaries are fed from a 2300 volt bus which is interconnected through transformer banks with the main bus.

On April 2 Col. William Kelly, Director of Engineering of the National Electric Light Association, spoke to the members of the Society on the subject of "Water-Power Development in the United States." Colonel Kelly was formerly Chief Engineer of the Federal Power Commission.

The next meeting of the Society will be held on Friday, April 23, at which time Dr. William E. Wickenden, Director of Investigation of the Society for the Promotion of Engineering Education, will address the members. Dr. Wickenden was formerly a professor at the Institute, and more recently vice-president of the American Telephone and Telegraph Company.

On May 7 a Student A.I.E.E. Convention will be held at the Institute in which practically all of the engineering colleges in New England and New York State are expected to participate. In the morning a number of papers will be presented by students, and in the afternoon inspection trips will be arranged to points in and about Boston of interest to electrical engineering students. In the evening a banquet will be held jointly with the Boston Section, after which Dr. M. I. Pupin, President of the American Institute of Electrical Engineers, and Mr. R. E. Doherty, of the General Electric Company, will speak.

CHEMICAL SOCIETY

Dr. Warren K. Lewis, in charge of the Department of Chemical Engineering at the Institute, and Mr. W. P. Cutter, Jr., of the Information Department of A. D. Little, Inc., were the speakers at the monthly meeting of the undergraduate Chemical Society.

The subject chosen by Dr. Lewis was "Some Brief Sketches in the History of Chemistry." He commented particularly on the two outstanding chemists of the nineteenth century, Faraday and Pasteur, and drew his conclusions from them, showing that the scientific men of a century ago were not as ignorant as many people today believe.

Mr. Cutter spoke on "The Value of the Study of Chemical Literature." He emphasized the importance, to anyone pursuing chemistry as a profession, of the ability to read foreign languages, particularly the German language. He cited many incidents to prove his point that there was an uncovered mine of knowledge in the literature. One of the most interesting of these was the case of opening up a government station in Logan County, Utah, where, after purchasing the needed equipment, the remaining funds were used to purchase a library. This library was in continual use at the station. Two years after the station was opened, there came a great number of people into Logan County in quest of gold. Desiring to have their findings assayed, they brought them to the government station. Mr. Cutter, upon whom the task of assaying the ore fell, consulted the literature, and although this was the first time he had ever assayed ore, he did it with great ease and success.

The Society also arranged a trip to the Revere Sugar Refinery in Charlestown, Mass. The men making the trip were shown through the entire refinery. The story of the refining of sugar, from unloading the crude sugar from shipboard, through the filtration through enormous bone-char filters, to the final crystallization in vacuum pans was explained.

Gas-Electric Rail Car. The J. G. Brill Company and Westinghouse have co-operated to produce an interesting rail car. One of the outstanding advantages of this particular car is that its trucks, and electric driving motors mounted on them, are the standard type in use in interurban service and are directly available.

The engine used is of special design by Brill, and is built by Westinghouse. It is a six-cylinder water-cooled unit developing 250 h.p. Mounted on the same base with it, and direct connected, is a standard Westinghouse generator. The motor-generator unit is mounted on rubber blocks, with its axis in the longitudinal center plane of the car, to minimize transmission of vibration to the car body. The control is of the electro-pneumatic type. —*Automotive Industries.*

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Engineers and Contractors
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Power Plant Apparatus
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Figure and Find Out!

It's a mistake to think of gas only from the point of first cost. Look deeper.

Sharpen your pencil. Figure out what it is costing you *not* to use gas. Thousands of manufacturers have convinced themselves and have changed to gas.

Better product and increased production are two of many advantages in using gas.

Why not send today for our new book, "Gas—The Ideal Factory Fuel"? It may open your eyes to unthought-of economies.

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Four Advantages of Gas

Dependable— any time, any place, any quantity.

Economical— lowest final cost per unit of production.

Controllable— exact temperatures, automatically controlled.

Clean— comfortable factory working conditions.

YOU CAN DO IT BETTER WITH ·· GAS ··

Editorials

(*Continued from page 67*)

jects already included therein, but by including purely cultural and some valuable commercial subjects. Most of the answers indicated that English and Public Speaking courses are of tremendous value in this age of high-pressure salesmanship, when even the pure scientist needs the ability to "sell" his discoveries to the scientific world.

This brings to mind the instance of the Tech student who went to Dean Talbot with the request that he be allowed to dodge all subjects not of a strictly scientific or engineering nature. He received the answer which should be in the minds of a number who have been heard to criticize the Institute curricula. He was told that the Institute was founded by men who realized the engineer's need of something in addition to engineering information and knowledge of science. Those men succeeded in planning and operating in a practical way the courses which have spelled success for so many of their graduates. No student here has any business trying to thwart their plans, which are of proved wisdom.

Of the two roughly divided classes of graduates of the Institute, the engineer and the scientist, the latter probably needs less study of a general nature than the other. But one of the important reasons which even he has for valuing a degree from M.I.T. over any other lies in the fact that he has had the breadth of education which the alumni of other engineering colleges may clamor for.

Lewis Cantilever Girder. A great deal of difficulty has been encountered in cutting the first 8000 feet of the Moffat Tunnel, due to the soft material through which it runs. It was found that arch members could not be kept in place while the benches were being removed and that the 12 x 12-inch sixteen foot legs under the wall plate bulged out and broke. This was due to the slips in the rock, which dips towards one side. Therefore considerable weight was thrown on the south side of the tunnel. Although 12 x 16-inch legs were tried, they too were unable to stand the pressure, which also split the 12 x 16-inch wall plate. The wall plate difficulty was solved by using a 14-inch steel I-beam for a wall plate. The other problem was finally solved by George Lewis, manager of the tunnel commission.

The Lewis Cantilever Girder is a device designed to support the weight of seventeen feet of arch timbers while the bottom of the tunnel is being excavated and permanent legs are being put in place. The device essentially consists of two parallel three and one-half foot plate girders, sixty feet long, spaced on six foot centers with the necessary cross frames and bracings. This is carried on two pairs of dollies, with ball and socket joints, which permit guiding of the girders and rolling them on a fifteen inch I-beam track laid on 12 x 12-inch stringers. Arms extending horizontally from the girders and at right angles to them are suspended from the overhanging end of the beam, and are provided with positive horizontal and vertical movement.

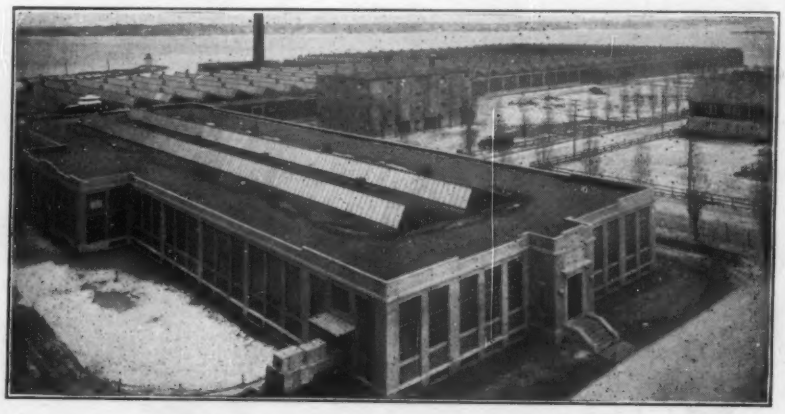
In operation the cantilever girder is on the track laid on top of the bench in the completed top section of the tunnel. The forward end of the girder is blocked against the roof timbers by means of I-beams and powerful jacks. The arms are rolled out from the rear end of the girder under the wall plates, whereupon they are blocked horizontally to prevent the wall plates from moving in. The entire arm is then raised vertically, by means of a wedge which is operated by a rod with a right and left hand thread, until the weight of the wall plates and roof timbers is carried by the girder. The bench is then drilled and shot out and the broken rock mucked out. After seventeen feet of bench has been removed, the permanent plumb posts are set and the cantilever beam moved forward on its track.

This device has not only speeded up progress and greatly reduced costs, but absolutely holds the arches and wall plates in their true position.—*A. E. Anderson in Du Pont Magazine.*

Compressing Steam. In the past, industry has considered it cheaper to generate steam at high pressures than to generate it at low pressures and compress it mechanically. It has been demonstrated recently that it is more economical for industries where most of the steam is used at low pressure to compress this steam to supply their high pressure needs. The compression is done by means of an ordinary air compressor, with slight modifications, driven by an electric motor. This is particularly applicable to heating drying ovens. Here it avoids the construction of a duplicate system of steam distribution or the use of electricity, which is an expensive source of heat. —*Power.*

Superpower, its Genesis and Future. By W. S. Murray. New York: McGraw-Hill, 1926. 237 pp.

This book, by the Chairman of the U. S. Superpower Survey, is an authoritative presentation of the electric power situation in the region between Washington and Boston. Technical details are completely dispensed with, and the style is a popular one, with a considerable amount of interesting and valuable economic data included. Chapters are devoted to the questions of public versus private ownership, railroad electrification, interstate relations and control by public service commissions and the Federal Power Commission, and financing. If the author has somewhat under-estimated the foresight and the soundness of the planning of the engineers associated with the large developments before the Superpower Survey was undertaken, this is certainly excusable, because the collection and collation of the data presented in the Superpower Report (Professional Paper 123, U. S. Geological Survey) are of immense value to the profession.



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Paving the Delaware River Bridge Approaches with

GRANITE BLOCK

The Granite Paving Block

is an engineering product —*not a cobblestone*

The improved granite paving block is finished to specifications. These specifications require that the head of the block, the wearing surface, shall have no greater depression than 3/8 in. The improved granite paving block, smooth and accurate, laid with the modern tight (1/2 in.) mastic filled joints, results in a smooth, quiet, dustless pavement of almost eternal durability.

The Granite Paving Block Mfrs. Assoc. of the U. S. Inc.
31 State Street, BOSTON, MASS.

Representing The World's Greatest Granite Quarries

GRANITE PAVING BLOCK MANUFACTURERS ASSN OF U.S. INC

GRANITE·LIVES·FOREVER

X-Rays

(*Continued from page 76*)

reproduced to show the great possibilities of relating characteristic properties with ultimate structures, and of controlling and improving manufacturing technic by this method.

In concluding, it should be emphasized that although X-ray methods lead to fundamental information about metals which can be obtained in no other way, they are conceived not to replace but to supplement microscopic methods. Intimate co-ordination of the new X-ray tool with the well-established microscopic methods holds high promise for further advances in the science of metals.

BUFF Instruments

save time—error—calculation

Engineers and contractors know that BUFF performance is accurate and sure—on all sorts of work, from running location lines to giving "neat lines" on important bridgework—without having to adjust the transit once.

Write for the BUFF Catalog No. 20M

Buff & Buff Mfg. Co.
Jamaica Plain, Mass.

BUFF

Metalclad Airships

(*Continued from page 59*)

permits doing most of the work by production methods on or near the floor.

With the MC-2 the gas, either hydrogen or helium, will be put in under a slight pressure while the hull is still in a vertical position. This is done by direct displacement of the air that is removed at the lower or stern and including the impure mixture at the surface of separation. Careful analysis shows that the latter, under proper conditions, need not exceed ten per cent. After inflation to a pressure insuring extra strength, the hull is hauled down to its designed position and the car bolted in place. Ordinary replenishment of buoyant gas will be by a service connection with the hull in normal position.

To have a ship such as the MC-2 as simple as possible to handle, not only in the air but also on the ground, is considered desirable. In both cases this is primarily a matter of aerodynamic stability, as before mentioned. These improvements applied to the MC-2 mean that it can be handled in the air by half the usual crew for a ship of its size, at the same time under much better control. It will also be possible to use very simple methods of mooring and ground handling. The principle of bow mooring is bound to be widely used, and it should be particularly appropriate to ships with improved stability, extra strength, and resistance to exposure. Our recent developments in mooring-tower construction are outside the scope of the present paper.

Due to its combination of perfect rigidity and its ability at the same time to carry considerable internal pressure, the Metalclad can be operated in flight either like a conventional rigid airship without reference to pressure, or like a non-rigid airship by watching the pressure manometer, and regulating the altitude accordingly. The latter method will be usually preferable, because in that way the hull can be kept full of gas and the maximum advantage taken of its extremely good gas-holding properties.

We are recommending that hydrogen gas be used for inflation on account of its availability, cheapness, lifting qualities, and the fact that it can be used for reserve fuel, which will reduce the weight of water ballast recovery apparatus. That hydrogen in a metal hull is at least as safe as gasoline in a metal tank should be fairly obvious. If helium is desired, however, it can be used to better advantage than in a fabric airship because of the almost negligible leakage through the metal hull, and the higher gas purity that can be maintained. Even with helium it is a great asset that the surface of the ship itself is fireproof.

Several questions have been raised as to the effect of the high thermal and electrical conductivities of the hull, the common idea being apparently that these would be unfavorable operating-factors. Actually they are just the reverse.

The metal surface heats up considerably in the sun, when not in motion, but this is usually an advantage at the start. In operation, thermal disturbances in the lift are eliminated by keeping the gas at the same temperature as the outside air. Indications are that the highly conductant metal surface tends to approach this ideal when in rapid motion through the air, most of the radiant heat being carried off again as fast as received.

In respect to electric conductivity, all authorities seem to be agreed that the new ship will be absolutely static proof and almost, if not entirely, lightning proof. The only danger conceivable from lightning is that a sudden charge might cause a momentary current so severe as to produce local fusion of the material. This has been observed in the case of wires where the current is restricted to a one dimensional flow, but for a flat surface it seems at least reasonable to suppose that any charge would splash out over enough area to prevent melting through.

SAMSON SPOT SASH CORD

Trade-Mark Registered U. S. Patent Office

Made of extra quality cotton yarn, carefully inspected, and guaranteed free from all imperfections of braid or finish. The colored spots are our trade-mark, used only with this quality.
We make braided cord of all sizes, kinds, and colors, for all purposes, including sash cord, clothes lines, trolley cord, signal cord, arc lamp cord, and many special cords for special purposes.

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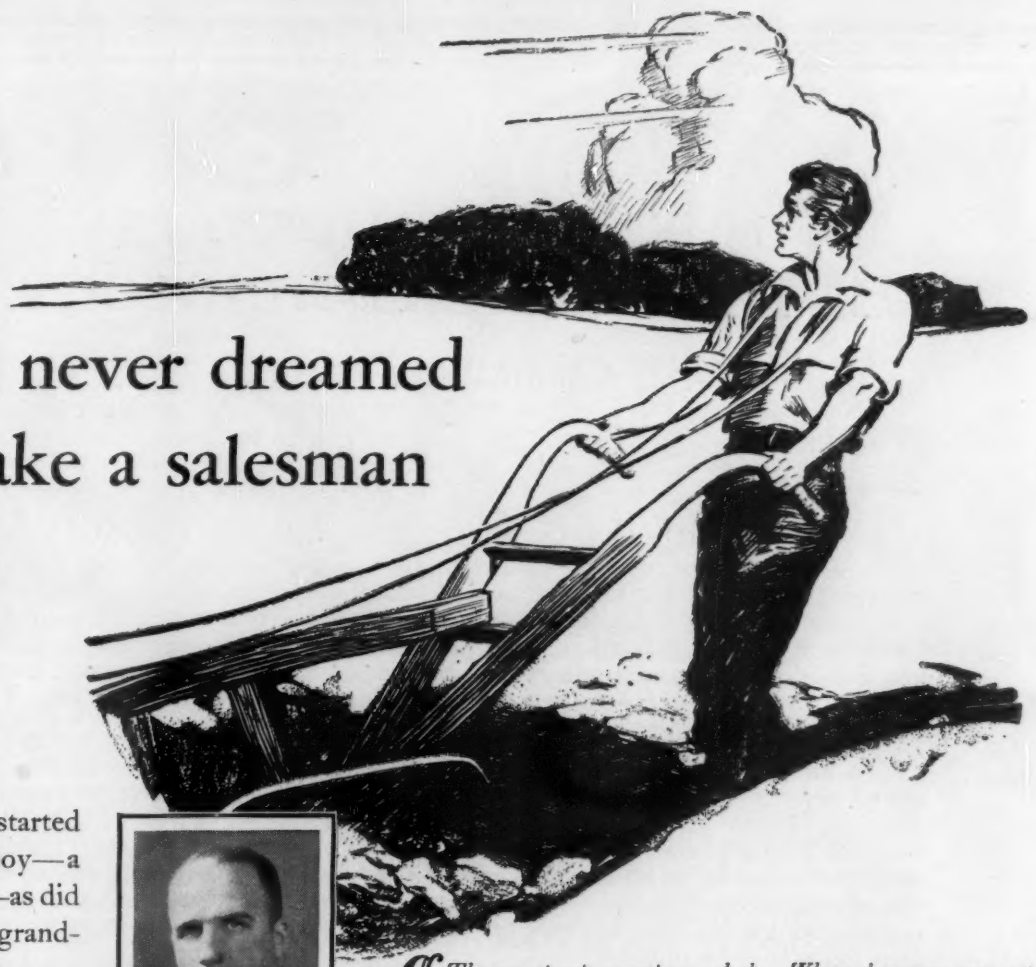
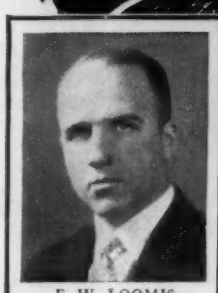


Loomis never dreamed he'd make a salesman



E. W. LOOMIS

The question is sometimes asked: Where do young men get when they enter a large industrial organization? Have they opportunity to exercise creative talents? Or are they forced into narrow grooves? This series of advertisements throws light on these questions. Each advertisement takes up the record of a college man who came with the Westinghouse Company within the last ten years or so, after graduation.

E. W. Loomis started life as a farmer boy—a real "dirt" farmer—as did his parents and grandparents before him.

Across the corn furrows, however, he would catch sight on the road of the only kind of engineer a farmer boy of that day saw—a civil engineer—and a civil engineer Loomis determined he would be.

At Delaware University, however, he got a job in the electrical laboratory—he also waited table, played football, wrestled, was commissary of the Commons, ran the battalion and did a number of other things, besides studying electrical engineering. One day a kindly professor said to him—"You understand men even better than you do electricity and engineering, why not go in for the sale of electrical apparatus?" Loomis liked the idea—came to Westinghouse—took the student course—then off to the New York Office as a "cub" salesman.

He worked—he always had—both on the farm and in college. In three years he was head of a section of the industrial sales department. By 1922 he was manager of the Industrial Division of the New York Office—charged with responsibility for the sale of Westinghouse apparatus to all industrial customers in New York State and in the northern half of New Jersey.

Loomis has fifty-two men working under his direction. It is barely eleven years since the wise old professor remarked to him—"Consider selling; it's a promising field."

Westinghouse

W
WESTINGHOUSE ELECTRIC

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CAMBRIDGE, MASS.

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY offers courses, each of four years' duration, in Civil, Mechanical, and Electrical Engineering; Naval Architecture and Marine Engineering; Mining Engineering and Metallurgy, and Geology; Architecture and Architectural Engineering; Chemistry, Chemical Engineering, and Electrochemical Engineering; Biology and Public Health, and Sanitary and Municipal Engineering; Physics, General Science, and General Engineering; and in Engineering Administration. These courses lead to the Degree of Bachelor of Science.

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Entrance examinations are held at the Institute in September. In June, applicants will be examined by the College Entrance Examination Board in Boston, New York, Philadelphia, Chicago, and many other cities in America and Europe. A circular stating times and places is issued in advance by the College Board.

Graduates of colleges and scientific schools of collegiate grade, and in general all applicants presenting satisfactory certificates showing work done at another college corresponding to at least one year's work at the Institute, are admitted, without examination, to such advanced standing as is warranted by their previous training.

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PUBLICATIONS

Bulletins of General Information, Courses of Study, Summer Session, Advanced Study and Research; and the Report of the President and the Treasurer.

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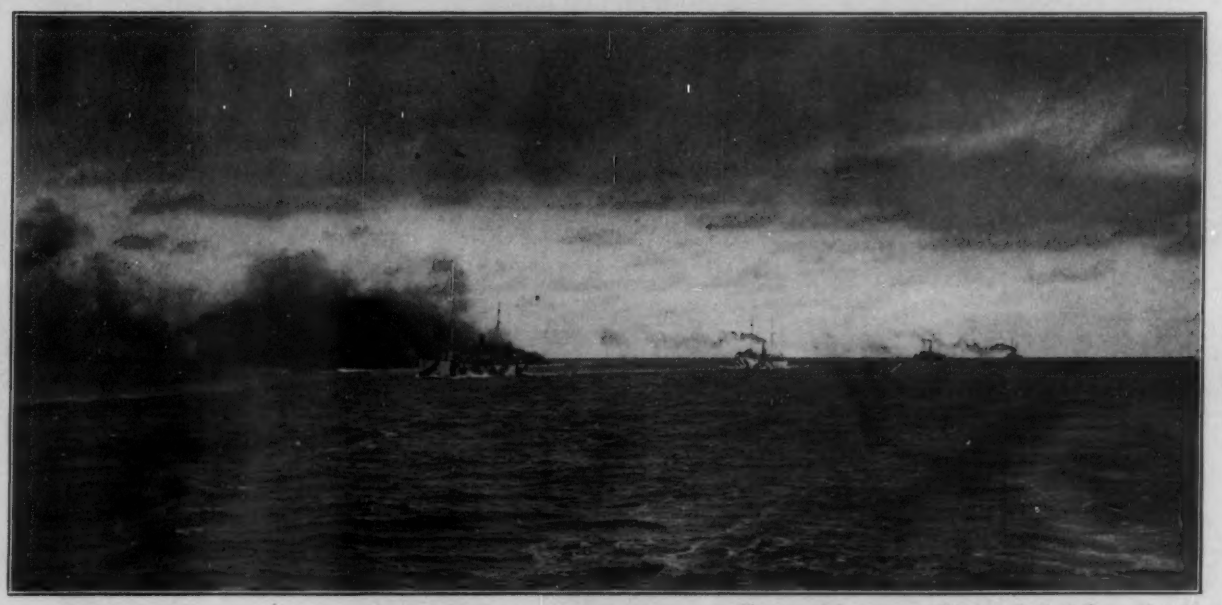

Photograph by courtesy of Captain R. R. Belknap, U. S. N.

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